BIOLOGICAL BULLETIN

OF THE

Marine Biological Laboratory

WOODS HOLE, MASS.

VOL. XLII JUNE, 1922 NO. 6

CONTENTS

PAGE

Twenty-Fourth Annual Report of the Marine Biological Laboratory . 275

KOPEĆ, STEFAN. *Studies on the Necessity of the Brain for the Inception of Insect Metamorphosis* 323

PUBLISHED MONTHLY BY THE
MARINE BIOLOGICAL LABORATORY

PRINTED AND ISSUED BY
THE NEW ERA PRINTING COMPANY, INC.
LANCASTER, PA.

AGENT FOR GREAT BRITAIN
WILLIAM WESLEY & SON
28 Essex Street, Strand, London, W. C.

Single Numbers, 75 Cents. Per Volume (6 numbers), $3.00

Entered October 10, 1902, at Lancaster, Pa., as second class matter under Act of Congress of July 16, 1894.

Editorial Staff

E. G. Conklin—*Princeton University.*

George T. Moore—*The Missouri Botanic Garden.*

T. H. Morgan—*Columbia University.*

W. M. Wheeler—*Harvard University.*

E. B. Wilson—*Columbia University.*

Managing Editor

Frank R. Lillie—*The University of Chicago.*

All communications and manuscripts should be sent to the Managing Editor, the University of Chicago, Sept. 15th to June 15th, or Woods Hole, Mass., June 15th to Sept. 15th. Subscriptions and other matter should be addressed to the Biological Bulletin, 41 North Queen Street, Lancaster, Pa

Vol. XLII. *June, 1922.* *No. 6.*

BIOLOGICAL BULLETIN

THE MARINE BIOLOGICAL LABORATORY.

TWENTY-FOURTH REPORT, FOR THE YEAR 1921, THIRTY-FOURTH YEAR.

I. TRUSTEES (AS OF AUGUST, 1921) 275
II. ACT OF INCORPORATION 277
III. BY-LAWS OF THE CORPORATION 277
IV. THE TREASURER'S REPORT 279
V. THE LIBRARIAN'S REPORT 283
VI. THE DIRECTOR'S REPORT 285
Statement 285
1. The Staff 290
2. Investigators and Students 293
3. Tabular View of Attendance 301
4. Subscribing and Coöperating Institutions 302
5. Evening Lectures 303
6. The Organization and Policies of the Marine Biological Laboratory 304
7. Members of the Corporation 310

I. TRUSTEES, AUGUST 9, 1921.

EX OFFICIO.

FRANK R. LILLIE, *Director,* The University of Chicago.
GILMAN A. DREW, *Assistant Director,* Marine Biological Laboratory.
D. BLAKELY, HOAR, *Treasurer,* 161 Devonshire Street, Boston, Mass.
GARY N. CALKINS, *Clerk of the Corporation,* Columbia University.

TO SERVE UNTIL 1925.

C. R. CRANE, New York, N. Y., *President of the Corporation.*
I. F. LEWIS, University of Virginia.

R. S. Lillie, Nela Research Laboratory.
E. P. Lyon, University of Minnesota.
C. E. McClung, University of Pennsylvania.
T. H. Morgan, Columbia University.
D. H. Tennent, Bryn Mawr College.
E. B. Wilson, Columbia University.

TO SERVE UNTIL 1924.

H. H. Donaldson, Wistar Institute of Anatomy and Biology.
W. E. Garrey, Tulane University.
Caswell Grave, Washington University.
M. J. Greenman, Wistar Institute of Anatomy and Biology.
George Lefevre, University of Missouri, *Secretary of the Board.*
A. P. Mathews, The University of Cincinnati.
G. H. Parker, Harvard University.
C. R. Stockard, Cornell University Medical College.

TO SERVE UNTIL 1923.

H. C. Bumpus, Brown University.
R. A. Harper, Columbia University.
W. A. Locy, Northwestern University.
Jacques Loeb, The Rockefeller Institute for Medical Research.
George T. Moore, Missouri Botanical Garden, St. Louis.
L. L. Nunn, Telluride, Colo.
W. J. V. Osterhout, Harvard University.
William M. Wheeler, Bussey Institution, Harvard University.

TO SERVE UNTIL 1922.

Cornelia M. Clapp, Mount Holyoke College.
E. G. Conklin, Princeton University.
Ross G. Harrison, Yale University.
* Camillus G. Kidder, 27 William Street, New York City.
M. M. Metcalf, Oberlin, Ohio.
William Patten, Dartmouth College.
Jacob Reighard, University of Michigan.
W. B. Scott, Princeton University.

* Deceased.

II. ACT OF INCORPORATION.

No. 3170.

COMMONWEALTH OF MASSACHUSETTS.

Be It Known, That whereas Alpheus Hyatt, William Sanford Stevens, William T. Sedgwick, Edward G. Gardiner, Susan Minns, Charles Sedgwick Minot, Samuel Wells, William G. Farlow, Anna D. Phillips and B. H. Van Vleck have associated themselves with the intention of forming a Corporation under the name of the Marine Biological Laboratory, for the purpose of establishing and maintaining a laboratory or station for scientific study and investigation, and a school for instruction in biology and natural history, and have complied with the provisions of the statutes of this Commonwealth in such case made and provided, as appears from the certificate of the President, Treasurer, and Trustees of said Corporation, duly approved by the Commissioner of Corporations, and recorded in this office;

Now, therefore, I, HENRY B. PIERCE, Secretary of the Commonwealth of Massachusetts, *do hereby certify* that said A. Hyatt, W. S. Stevens, W. T. Sedgwick, E. G. Gardiner, S. Minns, C. S. Minot, S. Wells, W. G. Farlow, A. D. Phillips, and B. H. Van Vleck, their associates and successors, are legally organized and established as, and are hereby made, an existing Corporation, under the name of the MARINE BIOLOGICAL LABORATORY, with the powers, rights, and privileges, and subject to the limitations, duties, and restrictions, which by law appertain thereto.

Witness my official signature hereunto subscribed, and the seal of the Commonwealth of Massachusetts hereunto affixed, this twentieth day of March, in the year of our LORD ONE THOUSAND, EIGHT HUNDRED and EIGHTY-EIGHT.

HENRY B. PIERCE,
Secretary of the Commonwealth.

[SEAL.]

III. BY-LAWS OF THE CORPORATION OF THE MARINE BIOLOGICAL LABORATORY.

I. The annual meeting of the members shall be held on the second Tuesday in August, at the Laboratory, in Woods Hole, Mass., at 12 o'clock noon, in each year, and at such meeting the members shall

choose by ballot a Treasurer and a Clerk, who shall be, *ex officio*, members of the Board of Trustees, and Trustees as hereinafter provided. At the annual meeting to be held in 1897, not more than twenty-four Trustees shall be chosen, who shall be divided into four classes, to serve one, two, three, and four years, respectively, and thereafter not more than eight Trustees shall be chosen annually for the term of four years. These officers shall hold their respective offices until others are chosen and qualified in their stead. The Director and Assistant Director, who shall be chosen by the Trustees, shall also be Trustees, *ex officio*.

II. Special meetings of the members may be called by the Trustees, to be held in Boston or in Woods Hole at such time and place as may be designated.

III. The Clerk shall give notice of meetings of the members by publication in some daily newspaper published in Boston at least fifteen days before such meeting, and in case of a special meeting the notice shall state the purpose for which it is called.

IV. Twenty-five members shall constitute a quorum at any meeting.

V. The Trustees shall have the control and management of the affairs of the Corporation; they shall present a report of its condition at every annual meeting; they shall elect one of their number President and may choose such other officers and agents as they may think best; they may fix the compensation and define the duties of all the officers and agents; and may remove them, or any of them, except those chosen by the members, at any time; they may fill vacancies occurring in any manner in their own number or in any of the offices. They shall from time to time elect members to the Corporation upon such terms and conditions as they may think best.

VI. Meetings of the Trustees shall be called by the President, or by any two Trustees, and the Secretary shall give notice thereof by written or printed notice sent to each Trustee by mail, postpaid. Seven Trustees shall constitute a quorum for the transaction of business. The Board of Trustees shall have power to choose an Executive Committee from their own number, and to delegate to such Committee such of their own powers as they may deem expedient.

VII. The President shall annually appoint two Trustees, who shall constitute a committee on finance, to examine from time to time the books and accounts of the Treasurer, and to audit his accounts at the close of the year. No investments of the funds of the Corporation shall be made by the Treasurer except approved by the finance committee in writing.

VIII. The consent of every Trustee shall be necessary to dissolution of the Marine Biological Laboratory. In case of dissolution, the property shall be given to the Boston Society of Natural History, or some similar public institution, on such terms as may then be agreed upon.

IX. These By-Laws may be altered at any meeting of the Trustees, provided that the notice of such meeting shall state that an alteration of the By-Laws will be acted upon.

X. Any member in good standing may vote at any meeting, either in person or by proxy duly executed.

IV. TREASURER'S REPORT.[1]

Harvey S. Chase & Company,
Certified Public Accountants, 84 State Street, Boston.

January 21, 1922.

Mr. D. Blakely Hoar,
161 Devonshire Street,
Boston.

Dear Sir: We have completed our audit of the accounts of the Marine Biological Laboratory for the year ended December 31, 1921, as kept both at your office in Boston and at Woods Hole, and report thereon in the accompanying exhibits and schedules:

Exhibit A—Balance Sheet as of December 31, 1921.
Exhibit B—Income and Expense for the Year ended December 31, 1921.
Schedule I—Investments (Book Values).
Schedule II—Cash Receipts and Disbursements on Account of Funds.
Schedule III—Land, Buildings, and Equipment.
Schedule IV—Supply Department Income and Expense Account for the Year ended December 31, 1921.

We certify that, subject to the comments herewith, the balance sheet and income and expense statement shown in Exhibits A and

[1] Only a part of the audit is included in the Treasurer's report. The complete audit is on file at the Laboratory and may be examined by any member.

B are in accordance with the books and correct to the best of our knowledge and belief.

Very respectfully,

(Signed) HARVEY L. CHASE & COMPANY,
Certified Public Accountants.

MARINE BIOLOGICAL LABORATORY BALANCE SHEET, DECEMBER 31, 1921.

Assets.

Cash:		
In bank	$1,548.37	
Petty cash fund	200.00	$1,748.37
Notes receivable (secured)		1,000.00
Accounts receivable		9,687.22
Inventories:		
Supply department	20,152.90	
BIOLOGICAL BULLETIN	3,535.95	23,688.85
Investments:		
Securities (Schedule I.) $11,694.87		
Less loan 1,500.00	10,194.57	
Cash (Schedule II.)	809.87	11,004.44
Stock in General Biological Supply House, Inc.		12,700.00
Gansett property account	20,754.95	
Less mortgage	11,582.01	9,172.94
Educational Plant (Schedule III.)		
Land	95,856.14	
Buildings	207,855.06	
Equipment	98,465.02	
	400,176.22	
Less reserve for depreciation	42,070.17	358,106.05
Deferred charges:		
Prepaid insurance		2,786.43
Items in suspense		336.98
		$430,251.28

Liabilities.

Accounts payable		$2,863.84
Notes payable:		
Falmouth National Bank		10,000.00
Accrued charges (estimated)		1,000.00
Items in suspense:		
Friendship Fund donation for 1922 expenses	$5,000.00	
Amount received from Marine Biological Laboratory Club for repairs to club house	500.00	
Other items	105.87	5,605.87
Trust funds		11,004.44
		$30,474.15

Balancing Account:			
Balance, January 1, 1921			$385,582.48
Add:			
Special Donations received during year for completing third floor of New Laboratory Building:			
Nela Research Laboratory	$3,000.00		
Eli Lilly Co	3,000.00		
Friendship Fund, Inc	1,500.00	7,500.00	
Balance of Income Account for Year (Exhibit B)		3,994.65	
Special Donations received in 1919 and 1920 towards purchase of stock of General Biological Supply House		2,700.00	399,777.13
			$430,251.28

Marine Biological Laboratory, Income and Expenses for Year Ended December 31, 1921.

	Expenses	Income	Loss	Gain
Administration expenses	$9,657.82		9,657.82	
Bar Neck Property expense	340.82		340.82	
Biological Bulletin and annual dues	4,186.35	3,537.15	649.20	
Biological Bulletin, adjustment of expenses for 1920		347.58		347.58
Carpenter department	1,044.09	7.58	1,036.51	
Chemical department	1,763.77		1,763.77	
Dormitories	2,609.21	2,467.62	141.59	
Instruction	6,915.60	8,882.50		1,966.90
Janitor's house expenses	7.68		7.68	
Interest on notes payable	570.00		570.00	
Library department	1,979.12		1,979.12	
Maintenance, buildings and grounds	6,919.63		6,919.63	
Mess	23,264.52	24,556.41		1,291.89
New laboratory	3,994.07		3,994.07	
Newman Cottage	73.90	150.00		76.10
Pumping station	514.83		514.83	
Research department	2,605.57	6,325.00		3,719.43
Sundry expense and income	1,241.89	9,243.76		8,001.87
Supply department (See Schedule IV.)	41,561.10	42,774.78		1,213.68
Truck	720.43		720.43	
Total current expenses	109,970.40		28,295.47	
Total current income	98,292.38	98,292.38	16,617.45	16,617.45
Excess of expenses	11,678.02		11,678.02	

Reserve for depreciation.....	7,270.69	
Bad accounts written off.....	204.64	
	19,153.35	
Donations for Expenses:		
Friendship Fund.. $20,000.00		
Frances C. Lillie... 3,000.00		
Other..... 148.00	23,148.00	
Balance to balancing account.....	$3,994.65	

Marine Biological Laboratory Investments, December 31, 1921.

Reserve Fund.

Cash on hand.....	$460.06	
*$3,000.00 American Telephone & Telegraph Company, 4's..	2,921.25	
500.00 Western Telephone & Telegraph Company, 5's...	496.88	
*6 shares American Smelting & Refining Company, Preferred.....	732.00	
8 shares General Electric Company.....	907.25	
14 shares United Shoe Machinery Corporation, Preferred...	393.75	
5 shares Massachusetts Gas Companies, Preferred.....	444.63	
	6,355.82	
Items marked * are held as collateral on loan of.....	1,500.00	$4,855.82

Library Fund.

$300.00 U. S. Liberty Loan, 4 1/4's.....	300.00	
4/5 of $1,000.00 American Telephone & Telegraph Company, 4's.....	779.00	
3 shares American Telephone & Telegraph Company.....	372.90	
3 shares General Electric Company.....	346.80	
5 shares United Shoe Machinery Corporation, Preferred...	140.63	
3 shares Massachusetts Gas Companies, Preferred.....	269.38	
1 share American Smelting & Refining Company, Preferred.	122.00	
	2,330.71	
Overdraft of cash.....	261.84	2,068.87

Lucretia Crocker Fund.

Cash on hand.....	611.65	
$300.00 U. S. Liberty Loan, 1st Convertible 4 1/4's.....	300.00	
1/5 of $1,000.00 American Telephone & Telegraph Company, 4's.....	194.75	
18 shares Vermont & Massachusetts Railroad Company.....	2,416.50	
3 shares General Electric Company.....	349.55	
1 share West End Street Railway Company.....	83.00	
1 share American Telephone & Telegraph Company.....	124.30	4,079.75
Total—Exhibit A.....		$11,004.44

V. REPORT OF THE LIBRARIAN.

The Library has enjoyed a steady growth since the previous report, the total number of books added to the Library being 929. Of these 78 volumes were received by purchase, 293 by binding of periodicals, 105 as gifts, and 26 as permanent loans from the American Museum of Natural History. To these should be added 427 reprints, mostly in pamphlet form. During the year the number of periodicals received has been 260 titles, of which 97 are received by subscription, 52 by exchange for the BIOLOGICAL BULLETIN, 99 are gifts, one is received by advertising, and 11 periodicals are sent to us from the duplicates of the American Museum of Natural History as loan. At the end of the year the total contents of the Library is 10,663 volumes and 8,959 pamphlets.

The Library has been fortunate in receiving a number of valuable gifts of books and of money. We may mention especially a gift of $50 from Miss Anna E. Lagemann, of $88 from Dr. Frank R. Lillie for the purchase of certain sets of journals, and $10 from Dr. Alfred G. Mayor for subscriptions to periodicals. Of books, we have received from the authors—

"The Nature of Animal Light," E. Newton Harvey.
"The Grand Strategy of Evolution," William Patten.
"Physiological Chemistry," 3d edition, Albert P. Matthews.
"Human Behavior," Stewart Paton.

From Messrs. Squibbs we have received their "Materia Medica," and from Messrs. Merck & Co., Benjamin L. Murray's "Standard Tests for Reagent Chemicals, 1920." An especially interesting gift is a volume of "Ramblers of a Naturalist, 1857," by de-Quatrefages. This book is given by Mr. William Beer, Librarian of the Howard Memorial Library of New Orleans. Mr. Beer visited Wood's Hole in the summer of 1920, was much interested in our Library, and has sent this book in recognition of the friendships then established. Dr. H. H. Donaldson has very kindly given us a copy of Cattell's "American Men of Science," edition 3, and from the Rev. Mr. Tingley we have received a copy of Porter, "The Human Intellect," and Barrett, "Threshold of the Unseen." The Librarian also wishes to express thanks for friendly sugges-

tions received from various members of the laboratory, especially Dr. Pond, Dr. Osterhout, and Dr. Franklin.

During the winter preceding the opening of the laboratory the Assistant Librarian rearranged the books in the Library, placing them in three series. Ordinary books are arranged at the west end of the Library and placed in order according to the Dewey decimal classification, the classification being somewhat minute with a view to future expansion. The journals are arranged in the next section of the Library and classified into a few broad classes. Under each class the journals are arranged alphabetically by title. The reprints are massed at the east end of the Library and are all arranged alphabetically. We have been able to complete ten important sets of journals by purchase, exchange, or gifts. Among the important ones that have been completed are—

Morphologisches Jahrbuch,
Quarterly Journal of Microscopic Science,
The New Phytologist,
La Cellule,
Proceedings of the Boston Society of Natural History.

The dictionary catalogue, which was started last year, now contains 8,637 cards. The use of the Library has increased considerably, the circulation for the year 1921 being 1,200 items. The new forms which have been devised for keeping records have proved very satisfactory and useful.

The needs of the Library are numerous and various. We may mention especially (1) reprints, of which none have been received recently from members of the laboratory. Authors are requested to look over the reprints in the Library when visiting Wood's Hole and to send us what are lacking; (2) larger appropriations are needed for the purchase of books much in demand; (3) special needs are—a good encyclopedia, bibliographical aids, such as the Zoölogical Record after 1893, the International Catalogue sections on botany, physiology, etc., from the beginning, The Royal Society Catalogue of Scientific Papers; and, finally, much more room is needed for the growth of the Library, and we are looking forward to this need being satisfied in the near future.

R. P. Bigelow,
Librarian.

VI. THE DIRECTOR'S REPORT.

To the Trustees of the Marine Biological Laboratory.

Gentlemen: I beg to present herewith a report of the thirty-fourth session of the Marine Biological Laboratory for the year 1921.

The session was in every sense a successful one; the attendance, which was far in excess of any previous year in the number of investigators, confirms again the status of the Laboratory as an effective organization for the promotion of biological research. The student attendance was the same as the preceding year, 120 in all courses, a number which has been fixed as a maximum with our present accommodations. The increase of the fee for courses from $50.00 to $75.00 first put into effect in 1921 thus did not operate to reduce attendance.

One hundred and seventy-two investigators, 36 more than in any preceding year, worked at the Laboratory. This was rendered possible by the completion of nine additional rooms in the brick building, with aid from the Nela Research Laboratory and Eli Lilly and Company acknowledged in the preceding report, by the use of five additional rooms in the newly completed laboratory of the Supply Department, and by assignments to the Laboratory of the Bureau of Fisheries at Wood's Hole generously placed at our disposal by the Commissioner, Dr. Hugh M. Smith. It would have been impossible to accommodate so many workers in the regular laboratories.

Fifty-two universities and colleges and research institutions subscribed for research rooms, or investigators' or students' tables (see appended list). This was the same number as in 1920, but the amount subscribed increased from $6,210.00 in 1920 to $8,800.00 in 1921. The total number of institutions represented by workers at the Laboratory was 95 scattered throughout practically all of the Eastern and Middle Western States. Workers from England, Holland, Russia, China, and Japan represented a growing international interest in the Laboratory.

Medical interests were represented by forty-one investigators and five students from twenty-seven medical institutions of this

country, Canada, England, and China. When it is considered what a high percentage of other investigators on the side of animal biology are concerned in teaching and investigation of pre-medical subjects, it is fair to say that the relation of the Laboratory to medical interests is very close indeed. This is, of course, not a new situation in the Laboratory, but it is one that is developing strength year by year.

It is probably worth while at this time to give a summary comparison of the finances of the Laboratory for the last six years, because the financing of educational institutions has been notoriously difficult owing to rising costs, and most readers of the report will not take the time to compare the detailed reports of the treasurer for successive years. The following table gives a summary of the chief items of interest for the last six years:

	Expense.	Earned Income.	Donations for Current Expense.	Surplus without Depreciation.
1916.....	$ 68,002.65	$52,776.87	$20,000.00	$ 4,774.22
1917.....	69,753.70	52,504.85	20,000.00	2,751.15
1918.....	69,687.14	54,282.05	20,000.00	4,594.91
1919.....	88,452.64	80,307.57	20,260.00	12,114.93
1920.....	103,097.64	89,943.04	20,060.00	6,905.40
1921.....	109,970.40	98,292.38	23,148.00	11,469.28

	Assets.	Liabilities.	Reserve for Depreciation.	Trust Funds.
1916.....	$329,845.93	$19,503.66	$ 6,942.12	$ 8,764.55
1917.....	382,943.30	19,500.40	8,881.82	9,285.59
1918.....	359,902.79[1]	17,019.79	21,140.24	9,954.03
1919.....	376,307.31	20,429.21	28,543.46	10,583.41
1920.....	411,123.63	27,263.50	34,799.48	10,409.66
1921.....	430,251.28	31,051.72	42,070.17	11,004.44

It will be observed that, in spite of the great increases in cost of operation (expense) during this time, the earned income has maintained a very satisfactory ratio, so that the fairly constant donation account has left a "surplus" each year, if such it may be called; this has all been used, together with the special gifts, acknowledged in the reports, for the additions and improvements that have been found necessary, such as rebuilding the mess hall, erection of the

[1] Decrease due to separate setting up of Gansett property account.

Supply Department Laboratory, completion of the brick building, increases of equipment, and in other minor ways, all of which are reflected in the increase of assets. The liabilities are made up for this table of the sum of accounts and notes payable, mortgage on the Gansett property and various lesser amounts, varying from year to year. The increase to be noted since 1918 is due mainly to loans amounting to $10,000 necessary to complete the heavy building and improvement operations of the last three years. The reserve for depreciation is merely a book charge diminishing the assets by the stated amount. The income of the small Trust Funds is allowed to accumulate, for the most part, and this accounts for their increase from year to year.

The treasurer's report for the current year (p. 279) reflects a satisfactory state of affairs so far as current expenses go. The increase of income over 1920, amounting to $8,349.34, is due to increase in receipts from instruction (from $5,960.00 in 1920 to $8,882.50 in 1921), from contributions for research rooms and tables ($4,450.00 and $6,325.00 in 1920 and 1921, respectively), from "Sundry Income," made up mostly of a charge of 6 per cent. on the investments in the mess, supply department, and dormitories ($7,030.75 and $9,243.76 in 1920 and 1921, respectively), and an increase of a little over $1,000.00 in the receipts from the mess. The receipts of the Supply Department, on the other hand, were nearly $1,000.00 less in 1921 than in 1920, which is, after all, a surprisingly small reduction in the face of the very adverse business conditions.

The new laboratory of the Supply Department and the additional rooms in the brick building were completed early in 1921 and were in use during the summer season.

Renewed and very careful consideration was given to the plans for the new buildings proposed in the reports for 1919 and 1920 and to means of securing funds for their construction and maintenance. A decision was soon reached to combine the three main needs, viz., a laboratory for biophysics and biochemistry, an auditorium, and library, in one building continuous with the present brick building, in order to use the land more economically, to simplify care of the buildings, and make the various departments more accessible to all workers; at the same time the plan provided

a quiet corner for the auditorium in the angle between the two wings protecting it completely from the noise of the street. In their work on these plans the Executive Committee were able to rely on the advice and assistance of Mr. Charles A. Coolidge, at every stage, as in the plans studied in the summer of 1920. Drawings were made by Messrs. Coolidge and Shattuck of Boston and were repeatedly criticized and improved, detail by detail, by the workers at the Laboratory. The plans reached an advanced state of completion by the end of the summer, and the architects were then instructed to prepare final drawings and specifications and to secure contractors' estimates on the cost of construction.

During the year also efforts were continued with the aid of the National Research Council to secure the necessary funds for the building and its endowment, estimated at about one million dollars. The project was presented to the Rockefeller Foundation and the Carnegie Corporation by officers of the National Research Council early in the year, and opportunity was given during the session by both organizations for a full presentation of the needs and plans of the Laboratory by our Executive Committee. Both organizations had the matter under favorable consideration at the end of the year.

We are not asking for a large endowment in connection with the new building, but for only enough so that the operation of the new addition should not be unduly burdensome. Our aim should be to develop and extend the system of contributions from research sources of all kinds and to expand the business of the Supply Department and of all other sources of revenue. The Laboratory should depend largely upon coöperative support, to the least possible extent upon endowment. The morale and strength of the organization depend upon the necessity of its members working together for its support and its growth. The Laboratory will thus best maintain its ideals and become increasingly effective in the advancement of science.

The membership of our Corporation and Board of Trustees is composed almost entirely of scientific men; such a body is not usually considered well qualified to deal with matters of investment connected with relatively large endowments. On the other hand, to create another body, as an integral part of the Laboratory, that

would have control of finances, would inevitably weaken the control of the scientific men over the policies of the Laboratory in general. Our Board of Trustees for these reasons adopted the policy that any endowment that should be created in connection with the present undertaking should be held in trust for the Laboratory by an outside body, which should pay in the income to the Laboratory for operating expenses.

If we realize these immediate aims within the next year or two, other practical problems will arise. The most serious of these probably is the housing problem which will be created by the increased attendance. This will be an important limiting factor in the growth of the Laboratory. There should be added a building capable of accommodating about 50 persons in separate rooms or small suites, situated as close to the Laboratory buildings and mess hall as possible. We should also erect about ten small bungalows, furnished and equipped for light housekeeping, on the Gansett tract, to accommodate some of our married members who can not now find reasonably priced and suitable accommodations for their families. About $75,000.00 is needed for these purposes. The rentals would furnish an addition to the income of the Laboratory, though it could not be expected to yield a high rate of return on the investment.

At the invitation of the Director, the Committee on Physiological Optics of the National Research Council held a session at the Laboratory from July 19 to July 22, inclusive. Advantage was taken of this occasion to hold several conferences on the general subject of biophysics between the members of the committee and investigators at the Laboratory. Demonstrations of biophysical investigations in progress were also held, and the sessions culminated in a symposium on "The Requirements of Biologists from Physical Science and on the Equipment of a Biophysical Laboratory." Numerous suggestions were received by the officers of the Laboratory for incorporation in the new plans. As one of the very few occasions in which the border-line problems between physics and biology have been discussed by specialists on both sides, the occasion was noteworthy. It should be regarded merely as a beginning of fruitful coöperation in biophysical research.

At the meeting of the Corporation August 9, 1921, four new

members were elected to the Board of Trustees in the class of 1925: Professor I. F. Lewis, of the University of Virginia; Dr. R. S. Lillie, of the Nela Research Laboratories; Professor E. P. Lyon, of the University of Minnesota, and Professor D. H. Tennent, of Bryn Mawr College.

As part of their report to the Carnegie Corporation the Executive Committee drafted a statement concerning the Organization and Policies of the Marine Biological Laboratory. As this is the first attempt at such a formulation, it is herewith printed (p. 304) as part of the Director's report for the criticism of the members of the Laboratory. It is not intended to constitute a set of regulations. It is descriptive of the practices that have grown up in the past thirty-four years and of the traditions that have been established; thirty-four years hence such a statement may have considerable interest, after those who were concerned in the early history of the Laboratory shall have departed from this scene.

There are appended as parts of this report: (1) A list of the staff for 1921, (2) A list of investigators and students in attendance in 1921, (3) A tabular view of attendance for the last five years, (4) A list of the subscribing and coöperating institutions in 1921, (5) The Evening Lectures, (6) A statement concerning the Organization and Policies of the Marine Biological Laboratory, (7) A list of members of the Corporation.

1. THE STAFF.

1921.

FRANK R. LILLIE, *Director*, Professor of Embryology, and Chairman of the Department of Zoölogy, The University of Chicago.
GILMAN A. DREW, *Assistant Director*, Marine Biological Laboratory.

ZOÖLOGY.

1. INVESTIGATION.

GARY N. CALKINS, Professor of Protozoölogy, Columbia University.
E. G. CONKLIN, Professor of Zoölogy, Princeton University.
GILMAN A. DREW, Assistant Director, Marine Biological Laboratory.
GEORGE LEFEVRE, Professor of Zoölogy, The University of Missouri.

FRANK R. LILLIE, Professor of Embryology, The University of Chicago.

C. E. MCCLUNG, Professor of Zoölogy, University of Pennsylvania.

T. H. MORGAN, Professor of Experimental Zoölogy, Columbia University.

E. B. WILSON, Professor of Zoölogy, Columbia University.

II. INSTRUCTION.

W. C. ALLEE, Professor of Biology, Lake Forest College.

EDWARD J. ADOLPH, Instructor in General Physiology, University of Pittsburgh.

ROBERT HALL BOWEN, Instructor in Zoölogy, Columbia University.

J. A. DAWSON, Professor of Biology, Dalhousie University.

C. L. PARMENTER, Instructor in Zoölogy, University of Pennsylvania.

CHRISTIANNA SMITH, Instructor in Zoölogy, Mount Holyoke College.

J. P. VISSCHER, Instructor in Zoölogy, Washington University.

DONNELL B. YOUNG, Assistant Professor of Zöology, Carlton College.

PROTOZOOLOGY.

I. INVESTIGATION.

(*See Zoölogy.*)

II. INSTRUCTION.

GARY N. CALKINS, Professor of Protozoölogy, Columbia University.

LOUISE H. GREGORY, Assistant Professor of Zoölogy, Columbia University.

EMBRYOLOGY.

I. INVESTIGATION.

(*See Zoölogy.*)

II. INSTRUCTION.

DAVID H. TENNENT, Professor of Biology, Bryn Mawr College.

HUBERT B. GOODRICH, Associate Professor of Zoölogy, Wesleyan University.

BENJAMIN H. GRAVE, Professor of Biology, Wabash College.

CHARLES G. ROGERS, Professor of Comparative Physiology, Oberlin College.

ELIZABETH A. SMITH, Assistant Professor of Zoölogy, University of Wisconsin.

PHYSIOLOGY.

I. INVESTIGATION.

ALBERT P. MATHEWS, Professor of Biochemistry, The University of Cincinnati.

HAROLD C. BRADLEY, Assistant Professor of Physiological Chemistry, University of Wisconsin.

WALTER E. GARREY, Professor of Physiology, Tulane University.

RALPH S. LILLIE, Biologist, Nela Research Laboratory, Department of Pure Science, Nela Park, Cleveland, Ohio.

II. INSTRUCTION.

RALPH S. LILLIE, Biologist, Nela Research Laboratory, Department of Pure Science, Nela Park, Cleveland, Ohio.

MERKEL H. JACOBS, Assistant Professor of Zoölogy, University of Pennsylvania.

FRANK P. KNOWLTON, Professor of Physiology, Syracuse University.

REYNOLD A. SPAETH, Associate in Physiology, School of Hygiene and Public Health, Johns Hopkins University.

PHILOSOPHICAL ASPECTS OF BIOLOGY AND ALLIED SCIENCES.

LECTURER.

EDWARD G. SPAULDING, Professor of Philosophy, Princeton University.

BOTANY.

I. INVESTIGATION.

S. C. BROOKS, Department of Public Health, Washington, D. C.

EDWARD M. EAST, Professor of Experimental Plant Morphology, Harvard University.

ROBERT A. HARPER, Professor of Botany, Columbia University.

E. NEWTON HARVEY, Assistant Professor of Physiology, Princeton University.

WINTHROP J. V. OSTERHOUT, Professor of Botany, Harvard University.

II. INSTRUCTION.

IVEY F. LEWIS, Professor of Biology, University of Virginia.

JACOB R. SCHRAMM, Professor of Botany, College of Agriculture, Cornell University.

WILLIAM RANDOLPH TAYLOR, Instructor in Botany, University of Pennsylvania.

LIBRARY.

ROBERT P. BIGELOW, Librarian and Associate Professor of Zoölogy and Parasitology, Massachusetts Institute of Technology. Librarian.
PRISCILLA B. MONTGOMERY (Mrs. Thomas H. Montgomery, Jr.), Assistant Librarian.

CHEMICAL SUPPLIES.*

OLIVER S. STRONG, Associate Professor of Neurology, Columbia University, New York City, Chemist.

SUPPLY DEPARTMENT.

G. M. GRAY, Curator.
JOHN J. VEEDER, Captain.
E. M. LEWIS, Engineer.
A. W. LEATHERS, Head of Shipping Department.
A. M. HILTON, Collector.
J. McINNIS, Collector.

F. M. MACNAUGHT, Business Manager.
HERBERT A. HILTON, Superintendent of Building and Grounds.

2. INVESTIGATORS AND STUDENTS—1921.

INDEPENDENT INVESTIGATORS—Zoölogy.

ADDISON, WILLIAM H. F., Professor of Histology and Embryology, University of Pennsylvania.
ADOLPH, EDWARD F., University of Pittsburgh.
ALLEE, WARDER C., Assistant Professor of Zoölogy, University of Chicago.
ALLEN, EZRA, Head of Biology Department, Ursinus College.
BAKER, HORACE B., Instructor, University of Pennsylvania.
BIGELOW, ROBERT P., Associate Professor of Zoölogy and Parasitology, Massachusetts Institute of Technology.
BORING, ALICE M., Associate Professor of Zoölogy, Wellesley College.
BOWEN, ROBERT H., Instructor in Zoölogy, Columbia University.
CALKINS, GARY N., Professor of Protozoölogy, Columbia University.
CAROTHERS, ELEANOR E., University of Pennsylvania.
CARROLL, MITCHELL, Professor of Biology, Franklin and Marshall College.

* Compound microscopes, with two oculars and two objectives, rack and pinion and fine adjustment, may be rented for the season at $7.00 each, provided notice is received by the Business Manager not later than June 1. Microscopes are not otherwise supplied by the Laboratory.

CHAMBERS, ROBERT, Assistant Professor of Anatomy, Cornell University Medical College.

CHARLTON, HARRY H., Assistant Professor, University of Missouri.

CHIDESTER, FLOYD E., Associate Professor of Zoölogy, West Virginia University.

CLAPP, CORNELIA M., Professor Emeritus of Zoölogy, Mount Holyoke College.

CLARK, ELIOT R., Professor of Anatomy, University of Missouri.

CLARK, ELEANOR L., Columbia, Mo.

COPELAND, MANTON, Professor of Biology, Bowdoin College.

COWDRY, E. V., Associate Member, Rockefeller Institute.

DANCHAKOFF, VERA, Assistant Professor of Anatomy, College of Physicians and Surgeons.

DANFORTH, CHARLES H., Associate Professor of Anatomy, Washington University School of Medicine.

DART, RAYMOND A., Demonstrator of Anatomy, University of London.

DAWSON, JAMES A., Professor of Biology, Dalhousie University.

DONALDSON, HENRY H., Professor of Neurology, Wistar Institute.

DREW, GILMAN A., Assistant Director, Marine Biological Laboratory, Woods Hole, Mass.

GALTSOFF, PAUL S., 278 Hawthorne Ave., Yonkers, N. Y.

GLASER, OTTO C., Professor of Biology, Amherst College.

GOODRICH, H. B., Associate Professor of Zoölogy, Wesleyan University.

GRAVE, CASWELL, Professor of Zoölogy, Washington University.

GRAVE, BENJAMIN H., Professor of Zoölogy, Wabash College.

GREGORY, LOUISE H., Assistant Professor of Zoölogy, Barnard College.

HAUSMAN, LEON A., Instructor in Biology and Protozoölogy, Cornell University.

HEMMETER, JOHN C., Professor, University of Maryland.

HEILBRUNN, LEWIS V., Assistant Professor of Zoölogy, University of Michigan.

HENSHAW, HENRY W., Washington, D. C.

HESS, WALTER N., Professor of Zoölogy, DePauw University.

HOGUE, MARY J., Instructor, Johns Hopkins University Medical School.

HOSKINS, MARGARET M., Medical College, University of Virginia.

HOWE, HARRISON E., Chairman Division Research Extension, National Research Council, Washington, D. C.

JACOBS, MERKEL H., Assistant Professor of Zoölogy, University of Pennsylvania.

JENNINGS, HERBERT S., Professor of Zoölogy, Johns Hopkins University.

JUST, ERNEST E., Professor of Zoölogy, Howard University.

KINDRED, JAMES E., Assistant Professor of Biology, Western Reserve University.

KNOWER, HENRY MCE., Professor of Anatomy, University of Cincinnati.

LEFEVRE, GEORGE, Professor of Zoölogy, University of Missouri.

LILLIE, FRANK R., Chairman, Department of Zoölogy, University of Chicago.

LINTON, EDWIN, Honorary Fellow in Zoölogy, University of Missouri.

MACCALLUM, G. A., 925 St. Paul St., Baltimore, Md.

MCCLUNG, C. E., Director of Zoölogical Laboratory, University of Pennsylvania.

MARTIN, BERTHA E., Associate Professor of Zoölogy, Mount Holyoke College.

MAST, SAMUEL O., Professor of Zoölogy, Johns Hopkins University.
MEDES, GRACE, Assistant Professor, Vassar College.
MINER, ROY W., American Museum of Natural History, New York City.
MORRILL, CHARLES V., Assistant Professor of Anatomy, Cornell University Medical College.
OKKELBERG, PETER, Assistant Professor of Zoölogy, University of Michigan.
PACKARD, CHARLES, Assistant Professor of Biology, Peking Union Medical College.
PARMENTER, CHARLES L., Instructor, University of Pennsylvania.
PATTEN, WILLIAM, Professor of Biology, Dartmouth College.
PEEBLES, FLORENCE, Bryn Mawr, Pa.
PINNEY, MARY E., Professor of Biology, Lake Erie College.
PLOUGH, HAROLD H., Associate Professor of Biology, Amherst College.
REESE, ALBERT M., Professor of Zoölogy, West Virginia University.
ROGERS, CHARLES G., Professor of Comparative Physiology, Oberlin College.
SCHRADER, FRANZ, Bryn Mawr College.
SHELLSHEAR, JOSEPH L., Demonstrator of Anatomy, University of London.
SLOSSON, EDWIN S., Editor of Science Service, Washington, D. C.
SMITH, ELIZABETH A., Assistant Professor of Zoölogy, University of Wisconsin.
SPAULDING, EDWARD G., Princeton University.
SPEIDEL, CARL C., Adjunct Professor of Anatomy, University of Virginia.
STOCKARD, CHARLES R., Professor of Anatomy, Cornell University Medical College.
STRONG, OLIVER S., Associate Professor of Neurology, Columbia University.
SWINGLE, WILTON W., Assistant Professor of Zoölogy, Yale University.
TENNENT, DAVID H., Professor of Biology, Bryn Mawr College.
TRACY, HENRY C., Professor of Anatomy, University of Kansas.
WHEDON, ARTHUR D., Instructor in Zoölogy, University of Pennsylvania.
WHITE, GERTRUDE M., Instructor, Carnegie Institute of Technology.
WHITESIDE, BEATRICE, 122 West 79th St., New York City, N. Y.
WHITING, PHINEAS W., Professor of Biology, St. Stephens College.
WOOD, F. E., Professor of Biology, Illinois Wesleyan University.

BEGINNING INVESTIGATORS—Zoölogy.

ATTERBURY, RUTH R., Instructor, College of Physicians and Surgeons, New York City.
BEAN, RAYMOND J., Instructor in Biology, Western Reserve University.
CHACE, EUNICE E., Instructor, Smith College.
DELLINGER, SAMUEL C., Assistant Professor, University of Arkansas.
GEIZER, SAMUEL W., Bruce Fellow, Johns Hopkins University.
GILSON, ARTHUR S., JR., Harvard University.
GUTHRIE, MARY J., Bryn Mawr College.
HAYDEN, MARGARET A., Instructor in Zoölogy, Wellesley College.
HIBBARD, HOPE, Assistant Professor of Biology, Elmira College.
HINRICHS, MARIE A., Instructor, Vassar College.
HOADLEY, LEIGH, University of Chicago.
JOHNSON, GEORGE E., Professor of Biology, University of Porto Rico.

LOWTHER, FLORENCE DEL., Instructor, Barnard College.
MCCOSH, GLADYS K., Assistant in Zoölogy, Washington University.
MCQUINN, LENORE, Graduate Student, University of Michigan.
MATAYOSHI, ZENKO, Assistant in Anatomy, Cornell University Medical College.
OHSHIMA, HIROSHI, Assistant Professor, Kyushu Imperial University.
RICHTER, MAURICE N., 1019 Trinity Ave., New York City.
ROMER, ALFRED S., Instructor, Bellevue Medical College.
SHEPPARD, ALICE E., 722 King St., Pottstown, Pa.
SIVICKIS, P., Fellow, Zoölogy Department, University of Chicago.
SMITH, CHRISTIANNA, Instructor, Mount Holyoke College.
SPRINGER, MARY G., Assistant in Zoölogy, Oberlin College.
SWETT, FRANCIS H., Assistant in Zoölogy, Yale University.
THARALDSEN, CONRAD E., Professor of Zoölogy, Northwestern University
TYREE, DORA, Assistant in Histology, University of Cincinnati.
UHLEMEYER, BERTHA, Instructor in Zoölogy, Washington University.
VARIAN, BASIL B., Columbia University.
VISSCHER, J. PAUL, Instructor, Washington University.
WARREN, HERBERT S., Assistant in Zoölogy, Columbia University.
WHITING, MRS. PHINEAS W., Annandale-on-Hudson, New York.
WOODBRIDGE, HELEN, Assistant in Zoölogy, Washington University.
WYMAN, LELAND C., Austin Teaching Fellow, Harvard University.
YOUNG, DONNELL B., Assistant Professor of Zoölogy, Carleton College.

INDEPENDENT INVESTIGATORS—Physiology.

BRADLEY, HAROLD C., Professor of Physiological Chemistry, University of Wisconsin.
CLOWES, GEORGE H. A., Director of Research Division, Eli Lilly & Co., Indianapolis.
COLLETT, MARY E., Instructor in Physiology, University of Buffalo.
COLLIP, JAMES B., University of Alberta, Alberta, Canada.
DAVIS, ALICE R., 19 Ash St., Cambridge, Mass.
EDWARDS, DAYTON J., Assistant Professor of Physiology, Cornell University Medical College.
GARREY, WALTER E., Professor of Physiology, Tulane University.
HARVEY, MRS. E. N., Princeton, N. J.
HARVEY, DR. E. NEWTON, Professor of Physiology, Princeton University.
HECHT, SELIG, Assistant Professor of Physiology, Creighton Medical College.
KNOWLTON, FRANK P., Professor of Phsiology, Syracuse University.
LILLIE, RALPH S., Biologist, Nela Research Laboratory, Cleveland, Ohio.
LOEB, JACQUES, Head of Division of Experimental Biology, Rockefeller Institute for Medical Research.
LOEB, LEO, Professor of Comparative Pathology, Washington University.
LYON, ELIAS P., Professor of Physiology, University of Minnesota.
MATHEWS, ALBERT P., Professor of Biochemistry, University of Cincinnati.
MOORE, ARTHUR R., Professor of Physiology, Rutgers College.
MORGULIS, SERGIUS, Professor of Physiological Chemistry, University of Nebraska, College of Medicine.
MORSE, WITHROW, Professor of Biochemistry, West Virginia University.

POND, SAMUEL E., Physiologist, Nela Research Laboratory, Cleveland.
SEVERINGHAUS, ELMER L., Instructor in Physiological Chemistry, University of Wisconsin.
SNYDER, CHARLES D., Professor of Experimental Physiology, Johns Hopkins University.
SPAETH, REYNOLD A., Associate in Physiology, School of Public Health, Johns Hopkins University.
VAN DER HEYDE, HENRI C., Heemstede, Holland.
WARREN, HOWARD C., Professor of Psychology, Princeton University.
WOODWARD, ALVALYN E., Demonstrator in Biology, Amherst College.

BEGINNING INVESTIGATORS—Physiology.

BACHMAN, EDA, Research Chemist, Eli Lilly & Co., Indianapolis.
BASKERVILL, MARGARET L., Research Assistant, Nela Research Laboratory, Cleveland, Ohio.
BILLS, CHARLES E., Graduate Student, Johns Hopkins University.
BLANCHARD, KENNETH C., Assistant in Biology, Clark University.
CATTELL, WARE, Student, Cornell University.
NI TSANG, G., University of Michigan.
PAGE, IRVINE H., Chemist, Eli Lilly & Co., Indianapolis.
SAMPSON, MYRA M., Assistant Professor of Zoölogy, Smith College.
SMITH, HOMER W., Eli Lilly & Co., Indianapolis.
SMITH, CARLOTTA G., Eli Lilly & Co., Indianapolis.
WOLLF, NAT S., Rochester, N. Y.

INDEPENDENT INVESTIGATORS—Botany.

BROOKS, SUMNER C., Hygienic Laboratory, United States Public Health Service.
BROOKS, MRS. S. C., Hygienic Laboratory, United States Public Health Service.
GATES, REGINALD R., Professor of Botany, Kings College, University of London.
HARPER, R. A., Professor of Botany, Columbia University.
HAZEN, TRACY E., Assistant Professor of Botany, Columbia University.
INMAN, O. L., Harvard University.
JONES, LEWIS R., Professor of Plant Pathology, University of Wisconsin.
LEWIS, IVEY F., Professor of Biology, University of Virginia.
MOORE, GEORGE T., Director Missouri Botanical Garden, St. Louis, Mo.
OSTERHOUT, WINTHROP J. V., Professor of Botany, Harvard University.
PHILLIPS, EVERETT F., Apiculturist, Department of Agriculture, Washington.
SCHRAMM, J. R., Professor of Botany, Cornell University.
TAYLOR, WILLIAM R., Instructor in Botany, University of Pennsylvania.

BEGINNING INVESTIGATORS—Botany.

DEBORD, GEORGE G., Research Fellow in Hygiene, Harvard Medical School.
GERSHAY, ALEXANDER, Assistant in Botany, Columbia University.
HUTCHINSON, DOROTHY M., Auburn, Maine.
KELLEY, ARTHUR P., Assistant in Botany, University of Pennsylvania.
MACINNES, FRANCES J., Massachusetts Institute of Technology.
MENESES, LAURA, Radcliffe College.

MUENSCHER, W. C., Instructor, Cornell University.
RAY, GEORGE B., Teaching Fellow, Harvard University.
SMITH, EDITH P., Edinburgh, Scotland.

STUDENTS.

1921.

ZOÖLOGY.

ABBOTT, ELIZABETH T., Vassar College.
ADCOCK, FLORENCE G., Student, Knox College.
ALLAN, ISABELLE, Hunter College.
ANASTASIA, CARMELA, Student, Connecticut College.
ATLEE, JOHN L., JR., Student, Franklin and Marshall College.
BENEDIX, AGNES W., Teacher, Hunter College High School.
BENNET, AGNES H., Student, Barnard College.
BOLLMAN, LORETTA M., Instructor, Notre Dame College.
BROWN, FRANCES T., Oberlin College.
BROWN, ROLAND W., Instructor, Pennsylvania Forestry School.
BULLOCK, EMILY W., Laboratory Assistant, Mount Holyoke College.
CALEF, DOROTHY A., University of Chicago.
CHASE, RUTH W., Assistant in Zoölogy, University of Wisconsin.
CORNELL, MILDRED, Student, Knox College.
COUNCIL, FRANK E., Instructor, Texas Christian University.
DAVIDSON, JOHN G., Principal, Delmont High School.
EMMART, EMILY W., Student, Goucher College.
EVERETT, M. GERTRUDE, Student, Knox College.
FISHER, MARY J., Instructor in Zoölogy, Cornell University.
FLEXNER, LOUIS B., Student, University of Chicago.
GEER, GERTRUDE H., Student, Sweet Briar College.
GOING, ELLEN M., 130 McTavish St., Montreal, Canada.
GREGG, MABEL J., Assistant in Zoölogy, University of Wisconsin.
GREGORY, ALLENE, Washington, D. C.
HUBER, CHARLES B., Student, Franklin and Marshall College.
HUSTED, GLENN, Student, Illinois Wesleyan University.
IVES, FLORENCE B., Sweet Briar College.
JOHNSON, ALFRED M., Student, Wabash College.
JORDAN, EDWIN P., Student, University of Chicago.
JOY, EDWARD A., Instructor in Biology, Tufts College.
LINCOLN, N. STANLEY, Student, Wesleyan University.
MCCAA, FANNY, Assistant Instructor, Agnes Scott College.
MCCARTY, SARAH H., Student, Barnard College.
MCGAVRAN, EDWARD G., Student, Butler College.
MARKEE, LOIS E., Student, Knox College.
MASBACH, HENRIETTA, Student, Goucher College.
MEDWEDEFF, MINNIE V., Goucher College.

MURRAY, MARGARET R., Student, Goucher College.
MYERS, EVERETT C., Student, Adelbert College, Western Reserve University.
NICHOLS, ELIZABETH, Student, Agnes Scott College.
NICHOLS, RHODA, Student, Wellesley College.
PELL, ORLIE A. H., 112 East 74th St., New York City.
SCOTT, HELEN M., Instructor, Illinois Wesleyan University.
SMITH, ABIGAIL E., Student, Wellesley College.
STEWART, DOROTHY R., Mount Holyoke College.
STOLL, IONE, Student, Hunter College.
UNGER, W. BYERS, Instructor in Biology, Lafayette College.
VREELAND, MAEBELLE, Student, Western State Normal School.
WICKS, NINA A., Student, Knox College.
WILSON, CONSTANCE C., Student, Wellesley College.
WOODHEAD, ARTHUR E., Professor of Chemistry and Biology, Western Maryland College.
WOODWARD, MILDRED, Student, Smith College.
YOUNG, BENJAMIN P., Assistant Professor of Zoölogy, Cornell University.

PROTOZOÖLOGY.

AUSTIN, MARY L., Laboratory Assistant in Zoölogy, Wellesley College.
BUCK, RUTH, University of Missouri.
BURNS, ROBERT K., Assistant in Zoölogy, Yale University.
FRY, HENRY J., Assistant in Zoölogy Department, Columbia University.
GREEN, WILMOTH, Assistant in Zoölogy Laboratory, Washington University.
LELAND, STANLEY J., DePauw University.
MACDOUGALL, MARY S., Head of Biology Department, Agnes Scott College.
MARTINAGLIA, GIOVANNI, Rockefeller Institute, Princeton.
MELENEY, GRACE C., Columbia University.
MENNINGER WILLIAM C., Cornell University Medical College.
METCALF, RACHEL V., Instructor, Mount Holyoke College.

EMBRYOLOGY.

BISHOP, MABEL, Head of Department of Biology, Hood College.
BOTSFORD, E. FRANCES, Instructor in Physiology, Mount Holyoke College.
BRAILEY, MIRIAM E., Student, Mount Holyoke College.
BUMPUS, LAURIN D., Student, Brown University.
CASEY, GERTRUDE U., Student, Simmons College.
DIMICK, GERTRUDE P., Student, Smith College.
EDINGTON, ROBERT P., Student, Wabash College.
GOULD, ALICE, Technician in Public Health, Yale University.
GRANT, MADELINE P., Graduate Student, Radcliffe College.
GRAY, JULIUS C., Williams College.
HARTWELL, RHODA A., Student, Mount Holyoke College.
HEATON, LOUISE M., Student, Mount Holyoke College.
HILL, CONSTANCE A., Student, Connecticut College.
HOWARD, NELSON J., Johns Hopkins University.
KLEMM, RALPH A., Student, Haverford College.

Mall, Mary L., Johns Hopkins Medical School.
Martin, Earl A., Student, College of the City of New York.
McClay, Edith L., Cornell University Medical College.
Myer, George A., Student, Johns Hopkins University.
Nute, Bertha E., 53 Hotchkiss Place, Torrington, Conn.
O'Toole, George B., Professor of Philosophy, St. Vincent's Archabbey.
Stilwell, Frances, Student, Smith College.
Titus, Jessie, Assistant, Long Island College Hospital.
Uichanco, Leopoldo B., Fellow in Entomology, University of the Philippines.
Warren, William A., Student, Dartmouth College.
Waterhouse, Isabel R., Student, Mount Holyoke College.
Williams, S. Culver, Wesleyan University.
Yolton, Leroy W., Illinois Wesleyan University.

PHYSIOLOGY.

Barnes, Hilda, Student, Smith College.
Brown, Alice L., Instructor in Zoölogy, Kansas State Agricultural College.
Chadbourne, Emily R., Bryn Mawr College.
Hausmann, Theo. W., Instructor in Science, Concordia Collegiate Institute.
Hoffman, Hannah G., Student, Barnard College.
Hultman, Jennie E., Teacher of Biology, Omaha.
Lowman, Edith, Student, Vassar College.
Millikin, Neil, Student, Johns Hopkins University.
Oslund, Robert, University of Chicago.
Pearse, Herman E., Jr., Student, University of Missouri.
Pinkerton, Florence A., Student, Simmons College.
Rathbone, Josephine L., Wellesley College.
Tilden, Evelyn B., Rockefeller Institute for Medical Research.
Walters, Mary J., Goucher College.
Webster, Eleanor F., Student, University of Pennsylvania.
Wong, A. D., Oberlin College.

Attending Morning Lectures only.

Harper, Francis D., 5728 Woodlawn Ave., Chicago, Ill.
Van Duyne, S. Elizabeth, Assistant Professor of Physiology and Hygiene, Goucher College.

BOTANY.

Adolph, Mary B., 3408 Wallace St., Philadelphia.
Chadbourne, Elisabeth, Student, Smith College.
Ferguson, George W., Student, Dartmouth College.
Hunt, Catherine T., Teacher, West Roxbury, Mass.
Hylander, Clarence J., Student, Yale University.
Keefe, Anselm, St. Norbert's College.
Kemp, Margaret, Student, Smith College.
Lackey, James B., Jackson, Miss.
MacCreight, Jean, 1358 Marlborough St., Philadelphia.
Mitchell, Esther, Student, Vassar College.

3. TABULAR VIEW OF ATTENDANCE.

	1917	1918	1919	1920	1921
INVESTIGATORS—Total	129	93	134	136	172
Independent:					
Zoölogy	63	51	68	69	79
Physiology	23	16	24	22	26
Botany	8	5	7	7	13
Under Instruction:					
Zoölogy	24	16	21	29	34
Physiology	6	3	10	7	11
Botany	5	2	4	2	9
STUDENTS—Total	83	69	128	120	120
Zoölogy	46	41	55	56	53
Protozoölogy	—	—	15	15	11
Embryology	16	12	33	26	28
Physiology	13	10	17	15	18
Botany	8	6	8	8	10
TOTAL ATTENDANCE	212	162	262	256	292
INSTITUTIONS REPRESENTED—Total	77	72	88	86	95
By investigators	60	49	61	55	67
By students	36	38	62	57	53
SCHOOLS AND ACADEMIES REPRESENTED.					
By investigators	2	—	—	1	—
By students	5	—	4	7	—

4. SUBSCRIBING AND COOPERATING INSTITUTIONS IN 1921.

Barnard College
Bowdoin College
Bryn Mawr College
Butler College
College of Physicians and Surgeons
Columbia University
Connecticut College
Cornell University
Cornell University Medical College
Creighton University
Dartmouth College
Eli Lilly & Co.
Federal Board of Vocational Education
Goucher College
Harvard University
Harvard University Medical School
Hunter College
Illinois Wesleyan University
Johns Hopkins University
Knox College
Massachusetts Institute of Technology
Mount Holyoke College
Nela Research Laboratory
Oberlin College
Princeton University
Radcliffe College
Rockefeller Foundation
Rockefeller Institute for Medical Research
Simmons College
Smith College
Tufts College
University of Chicago
University of Cincinnati
University of Illinois
University of Kansas
University of Michigan
University of Missouri
University of Nebraska
University of Pennsylvania
University of Philippines
University of Virginia
University of Wisconsin
Vassar College
Wabash College
Washington University
Wesleyan University
Wellesley College
Western Reserve University
Western State Normal School
Williams College
Wistar Institute of Anatomy and Biology
Yale University

Scholarship Tables.

The Lucretia Crocker Scholarships for Teachers in Boston, Since 1888.

Scholarship of $100.00, Supported by a Friend of the Laboratory, Since 1898.

The New London Branch of the American Association of University Women, Since 1920.

5. EVENING LECTURES, 1921.

Friday, July 1,
Dr. W. J. V. Osterhout....."Injury and Recovery."
Tuesday, July 5,
Dr. E. R. Clark....."The Reaction of Living Cells in the Tail of the Frog Larvæ to Foreign Substances."
Friday, July 8,
Dr. Gary N. Calkins....."Differentiation and Vitality in Protozoa."
Tuesday, July 12,
Dr. R. S. Lillie....."The Conditions of Growth in Living and in Non-living Systems."
Friday, July 15,
Dr. Wallace O. Fenn....."Phagocytosis."
Tuesday, July 19,
Dr. E. V. Cowdry....."The Conflict between Old and New Medicine in China."
Friday, July 22,
Dr. G. H. A. Clowes....."Some Physical Chemical Concepts of Protoplasmic Structure."
Tuesday, July 26,
Dr. H. H. Donaldson....."Rat Studies."
Friday, July 29,
Dr. I. W. Bailey....."The Significance of the Cambium in the Investigation of Certain Cytological and Physiological Problems."
Tuesday, August 2,
Mr. Wm. L. Underwood....."Adventures of a Sage-brush Tourist in Wyoming."
Friday, August 5,
Dr. E. E. Slosson....."History from the Standpoint of the Second Law of Thermo-dynamics."
Monday, August 8,
Dr. S. C. Brooks....."Immunity and Ultra-violet Light."

6. THE ORGANIZATION AND POLICIES OF THE MARINE BIOLOGICAL LABORATORY.

The Marine Biological Laboratory is an outpost of the higher educational and research institutions of the country. Representatives of such institutions are eligible to membership in the controlling body, the Corporation of the Marine Biological Laboratory, composed of over 400 persons, mostly biologists. Institutions also have further control and interest through their ability for a moderate sum to use assigned quarters for members of their staff or student body. They may thus from year to year continue to occupy the same quarters and possess veritable extra-territorial control. The Laboratory actually belongs to the biologists and through them to their institutions. The function of the administration of the Laboratory is the execution of a trust held for common use.

The organization thus provides for a nominal sum facilities that would cost each institution many times the amount to provide independently. This is important even for the largest institutions, and indispensable for all the smaller institutions that aim to maintain the research spirit of members of their staffs.

1. *Organization.*—The Marine Biological Laboratory is an independent Corporation operating under its own charter. The act of incorporation of the Marine Biological Laboratory and the By-laws of the Corporation are printed in each of the Annual Reports. The membership of the Corporation and of the Board of Trustees is also printed in the same places. The Corporation meets on the second Tuesday in August each year at the Laboratory. At each annual meeting it elects eight trustees to serve four years, and a Treasurer and Clerk of the Corporation who are *ex officio* members of the Board of Trustees; the Director and Assistant Director, who are appointed by the Trustees, are also *ex officio* members of the Board.

The Trustees, who are mostly biologists selected for their scientific attainments, have the control and management of the affairs of the Corporation; they, on their part, delegate most of their

functions to an executive committee of five members, including the Director and Assistant Director *ex officio*.

The membership of the Corporation represents all important phases of biological research and most American institutions in which such work is done. Any competent investigator qualified for admission to the principal national research societies in Biology is eligible for membership, which is also open to other persons willing and qualified to render useful service to the Corporation. (See rules of eligibility in the records of the Clerk of the Corporation.) The ultimate control and ownership of the Laboratory is vested in the Corporation.

2. *Purpose.*—The primary purpose of the Marine Biological Laboratory is the advancement of Biological Science. This is the first consideration in every matter of policy. The *scope* is conceived as broad as the field of biology, but the *aim* is to promote the fundamental and more general rather than the systematic and more special problems. The fundamental problems trace back to the cell, and are based ultimately on physics and chemistry; they thus require some of the special equipment of both of these fields. Considerations of pure science are primary and those of utility secondary, though recognized as important. Thus the work of the Laboratory bears important relations to medicine, agriculture, fisheries, and economic biology.

3. *Research.*—Individual research is the foundation of all advance in science. Hence all policies of the Laboratory are directed toward the investigator with the object of furnishing him opportunities, facilities, and freedom for research.

The Laboratory has no set program of research as an institution, but aims to be hospitable to all branches of biological science; it should thus reflect and stimulate progress in all directions, if not simultaneously, at least in the course of time.

It is the policy of the Laboratory to favor such forms of coöperation in research as develop naturally. The mere association of so many investigators as meet annually at the Laboratory inevitably develops coöperative relations of various kinds, and this is regarded as one of the most valuable results of the organization.

Investigators are admitted to the Marine Biological Laboratory

on the judgment of the Director as to their fitness to make good use of the facilities offered.

Two classes of investigators are recognized: those who work independently, and those receiving instruction in investigation.

Investigators' fees are generally paid by the institution to which the investigator belongs, but it is at the discretion of the Director to admit any investigator without charge, and it has never been the policy to refuse admission to any independent investigator solely on the issue of a fee.

The more experienced investigators, or a selected group thereof, guide the research of beginning investigators. No group in the organization will be of more significance for the future of the Laboratory than beginners in research.

Admission to the Laboratory is not limited by considerations of nationality. It has become desirable to pursue a positive instead of a merely passive or negative attitude in the matter of international representation.

The Laboratory is open to investigators throughout the year.

The Laboratory is open on the same terms to both sexes.

4. *Instruction.*—In pursuit of the primary purpose of the Laboratory it is essential that provision should be made for the production and training of investigators. It is important that a certain part of such provision should be in the Laboratory itself. Hence instruction of a strictly professional character is also a settled policy of the Laboratory. Experience has shown that instruction may be overemphasized to the detriment of research; hence the policy of the Laboratory is to limit the courses of instruction offered (only five for many years), to require fees adequate to pay all the expenses of instruction, to limit the numbers registered in each course, and to admit no one without satisfactory recommendations.

The intellectual atmosphere of the Laboratory is favorable in the highest possible degree to the development of the research spirit in young students. For their own sake and for the sake of the future development of biology they should not be excluded from the Laboratory.

In the case of all courses offered, the facilities of the Laboratory, whether of personnel or material, are such as to guarantee that

they may be offered to greater advantage here than elsewhere. There is no attempt to duplicate university or college courses.

The Laboratory assigns no grades in courses and sets no examinations. The Laboratory will therefore not certify to attainments in any course, but individual instructors are at liberty to do so on their own responsibility.

Instructors in courses are selected primarily for their interest in and qualifications for research.

Salaries of instructors are calculated to pay expenses of travel and living only for the duration of the course.

The number of instructors in courses is sufficient to leave each one adequate time for his own research.

Courses of instruction are given only during six weeks in the summer.

5. *Coöperating Institutions.*—The organization of the Laboratory, being primarily a coöperative society of biological investigators and of the institutions that they represent, is such that a system of subscribing and coöperating institutions has been gradually developed (see p. 302); these relationships should be further extended and strengthened.

As far as possible the same space is reserved in successive years for the coöperating institutions. But, except where definite contracts exist, the assignment of space is at the discretion of the Director.

The Laboratory aims to be an outpost of the biological departments of universities, colleges, and research laboratories; each has its part in the Laboratory according to its needs and acquired rights.

6. *Financial.*—In general, it is the aim of the Laboratory to make all departments except research self-supporting. The Laboratory should depend as little as possible upon actual endowment and as much as possible upon earnings and good will. It is the policy of the Laboratory to have endowment funds held in trust.

The financial administration should be such as to secure confidence; to this end there is a complete accounting system for all income and expenditures and an annual audit by a firm of auditors, which is published each year.

A budget estimate is prepared in December of each year for the

year following and submitted to the Board of Trustees, or Executive Committee, for consideration.

7. *Staff.*—The Assistant Director and operating staff on annual appointments receive their livelihood from the Laboratory; the salaries should be ample in order to secure the best men.

The scientific staff on the research side serves without salary; salaries of instructors are calculated to pay expenses of travel and living for the duration of the course.

There is no permanent scientific staff. The establishment of such a staff would tend to endanger the principle of freedom of development for all branches of biology by favoring a few. It would also set the Laboratory in competition with universities and research institutions for men and weaken the spirit of coöperation of such institutions. It would favor a few individuals at the expense of the many.

8. *The Supply Department* serves primarily to obtain and distribute living materials for research within the institution; class supplies are also furnished. This service is furnished without additional fee to investigators and students. This is an essential part of the organization. It saves the time of the investigators and through intelligent collecting depletion of the grounds is safeguarded.

The major part of the work of the Supply Department is, however, to furnish biological supplies to institutions. It is the policy to develop this business as far as possible. The main advantages are: (1) The profits from sales are an important item of income. (2) The business is continuous throughout the year, and the Laboratory is thus enabled to keep together a permanent skilled staff of collectors. (3) A real service is rendered to biological education and research by providing a source of standardized and reliable material of many kinds. (4) This service constitutes an important item of good-will.

9. *The Department of Chemical Supplies.*—In general, it is the function of this department to furnish all standard apparatus and supplies ordinarily used in the work of investigation at the Laboratory with no additional charge. Exceptions are noted in the printed rules of the department. Microscopes, microtomes, and

"special" apparatus and reagents are not furnished. The policy is summed up in "service to the investigator."

10. *The Library.*—It is the policy of the Laboratory to develop the best possible library for current biological research. Books of historical interest only are regarded as secondary in importance. The development of this policy will involve the establishment of a very large library in the course of time, and this should be pursued as rapidly as possible.

11. *The Mess* is conducted for the benefit of investigators and students. Rates are calculated to pay the cost of operation, equipment, rent, and upkeep in general, and not for profit.

Rules and regulations have been established governing its use. These are subject to revision by the Executive Committee of the Laboratory at any time.

12. *Housing Facilities.*—The housing facilities furnished by the Laboratory are calculated to meet the deficit in the local supply and to keep local prices at a reasonable rate. As the local provision has become progressively less adequate, it has been necessary to make increasing provision for workers. The purchase of the Gansett property, twenty acres within a mile of the Laboratory, was determined by this consideration. The development of the Laboratory obviously depends upon adequate housing facilities at reasonable rates.

13. *Biological Bulletin.*—One of the policies of the Laboratory should be to aid in the provision of adequate means for publication of biological research in America. The establishment of the BIOLOGICAL BULLETIN in 1899 was in pursuit of this policy; it is now in its forty-first volume. A larger responsibility should be undertaken as soon as means permit.

14. *Future Development.*—The policy of attempting adequately to represent biological research in America by free association of, and government by, the investigators themselves determines all questions of future development. The next step will generally be apparent, as, for instance, the present need of a biophysical and biochemical laboratory, and of a building for library, administration, and auditorium. It is the policy of the Laboratory to be ready for advance by the nature and morale of its organization and by control of sufficient land.

7. MEMBERS OF THE CORPORATION.

1. Life Members.

Allis, Mr. E. P., Jr., Palais Carnoles, Menton, France.
Andrews, Mrs. Gwendolen Foulke, Baltimore, Md.
Billings, Mr. R. C., 66 Franklin St., Boston, Mass.
Carey, Mr. Arthur Astor, Fayerweather St., Boston, Mass.
Clarke, Prof. S. F., Williamstown, Mass.
Conklin, Prof. Edwin G., Princeton University, Princeton, N. J.
Crane, Mr. C. R., Woods Hole, Mass.
Evans, Mrs. Glendower, 12 Otis Place, Boston, Mass.
Farlow, Prof. W. G., Harvard University, Cambridge, Mass.
Fay, Miss S. B., 88 Mt. Vernon St., Boston, Mass.
Folsom, Miss Amy, 88 Marlboro St., Boston, Mass.
Foot, Miss Katherine, 955 Park Ave., New York City, N. Y.
Gardiner, Mrs. E. G., Woods Hole, Mass.
Gardiner, Miss Eugenia, 15 W. Cedar St., Boston, Mass.
Harrison, Ex-Provost C. C., University of Pennsylvania, Philadelphia, Pa.
Jackson, Miss M. C., 88 Marlboro St., Boston, Mass.
Jackson, Mr. Chas. C., 24 Congress St., Boston, Mass.
Kidder, Mr. Nathaniel T., Milton, Mass.
King, Mr. Chas. A.
Lee, Mrs. Frederic S., 279 Madison Ave., New York City, N. Y.
Lowell, Mr. A. Lawrence, 17 Quincy St., Cambridge, Mass.
Marrs, Mrs. Laura Norcross, 9 Commonwealth Ave., Boston, Mass.
Mason, Miss E. F., 1 Walnut St., Boston, Mass.
Mason, Miss Ida M., 1 Walnut St., Boston, Mass.
Means, Mr. James Howard, 196 Beacon St., Boston, Mass.
Merriman, Mrs. Daniel, 73 Bay State Road, Boston, Mass.
Minns, Miss Susan, 14 Louisburg Square, Boston, Mass.
Minns, Mr. Thomas, 14 Louisburg Square, Boston, Mass.
Morgan, Mr. J. Pierpont, Jr., Wall and Broad Sts., New York City, N. Y.

MORGAN, PROF. T. H., Columbia University, New York City, N. Y.
MORGAN, MRS. T. H., New York City, N. Y.
NOYES, MISS EVA J.
NUNN, MR. LUCIAN L., Telluride, Colo.
OSBORN, PROF. HENRY F., American Museum of Natural History, New York City, N. Y.
PHILLIPS, DR. JOHN C., Windy Knob, Wenham, Mass.
PHILLIPS, MRS. JOHN C., Windy Knob, Wenham, Mass.
PORTER, DR. H. C., University of Pennsylvania, Philadelphia, Pa.
PULSIFER, MR. W. H., Newton Center, Mass.
ROGERS, MISS A. P., 5 Joy St., Boston, Mass.
SEARS, DR. HENRY F., 86 Beacon St., Boston, Mass.
SHEDD, MR. E. A.
SMITH, MRS. C. C., 286 Marlboro St., Boston, Mass.
THORNDIKE, DR. EDWARD L., Teachers College, Columbia University, New York City, N. Y.
TRELEASE, PROF. WILLIAM, University of Illinois, Urbana, Ill.
WARE, MISS MARY L., 41 Brimmer St., Boston, Mass.
WHITNEY, MR. HENRY M., Brookline, Mass.
WILCOX, MISS MARY A., Wellesley College, Wellesley, Mass.
WILLIAMS, MRS. ANNA P., 505 Beacon St., Boston, Mass.
WILSON, DR. E. B., Columbia University, New York City, N. Y.
WILSON, PROF. W. P., Commercial Museum, Philadelphia, Pa.

2. REGULAR MEMBERS, AUGUST, 1921.

ADDISON, DR. W. H. F., University of Pennsylvania Medical School, Philadelphia, Pa.
ADAMS, MISS A. E., Mount Holyoke College, South Hadley, Mass.
AGERSBORG, MR. H. P. K., University of Illinois, Urbana, Ill.
ALLEE, DR. W. C., University of Chicago, Chicago, Ill.
ALLEN, PROF. EZRA, Ursinus College, Collegeville, Pa.
ALLYN, MISS HARRIET M., 264 Jefferson Ave., New London, Conn.
ALTENBURG, DR. EDGAR, Rice Institute, Houston, Texas.
ANDERSON, DR. E. G., Carnegie Institution, Cold Spring Harbor, N. Y.

ATTERBURY, MRS. RUTH R., College of Physicians and Surgeons, New York City.

BAITSELL, DR. GEORGE A., Yale University, New Haven, Conn.

BAKER, MRS. L. D., 123 Chiswick Road, Boston, Mass.

BAKER, DR. E. H., 5729 Kimbark Ave., Chicago, Ill.

BALDWIN, DR. F. M., Iowa State College, Ames, Iowa.

BANCROFT, PROF. F. W., Aloha Farm, Concord, Calif.

BECKWITH, DR. CORA J., Vassar College, Poughkeepsie, N. Y.

BEHRE, DR. ELINOR H., Louisiana State University, Baton Rouge, La.

BIGELOW, PROF. M. A., Teachers College, Columbia University, New York City.

BIGELOW, PROF. R. P., Mass. Institute of Technology, Cambridge, Mass.

BINFORD, PROF. RAYMOND, Guilford College, Guilford College, N. C.

BORING, DR. ALICE M., Wellesley College, Wellesley, Mass.

BOX, MISS CORA MAY, University of Cincinnati, Cincinnati, Ohio.

BOWEN, DR. ROBERT H., Columbia University, New York City.

BRADLEY, PROF. HAROLD C., University of Wisconsin, Madison, Wis.

BRIDGES, DR. CALVIN B., Columbia University, New York City.

BRUMFIEL, DR. DANIEL M., University of Iowa, Iowa City, Iowa.

BUCKINGHAM, MISS EDITH N., 342 Marlboro St., Boston, Mass.

BUDINGTON, PROF. R. A., Oberlin College, Oberlin, Ohio.

BUMPUS, PROF. H. C., Brown University, Providence, R. I.

BYRNES, DR. ESTHER F., 193 Jefferson Ave., Brooklyn, N. Y.

CALKINS, PROF. GARY N., Columbia University, New York City.

CALVERT, PROF. PHILIP P., University of Pennsylvania, Philadelphia, Pa.

CARLSON, PROF. A. J., University of Chicago, Chicago, Ill.

CAROTHERS, DR. ELEANOR E., University of Pennsylvania, Philadelphia, Pa.

CARPENTER, PROF. FREDERIC W., Trinity College, Hartford, Conn.

CARROLL, PROF. MITCHEL, Franklin and Marshall College, Lancaster, Pa.

CARVER, PROF. GAIL L., West Lake, Ga.

CARY, DR. L. R., Princeton University, Princeton, N. J.

CASEY, COLONEL THOMAS L., Washington, D. C.
CASTEEL, DR. D. B., University of Texas, Austin, Texas.
CATTELL, PROF. J. MCKEEN, Garrison-on-Hudson, N. Y.
CATTELL, MR. MCKEEN, Harvard Medical School, Boston, Mass.
CHAMBERS, DR. ROBERT, JR., Cornell University Medical College, New York City.
CHARLTON, DR. HARRY H., University of Missouri, Columbia, Mo.
CHIDESTER, PROF. F. E., West Virginia University, Morgantown, W. Va.
CHILD, PROF. C. M., University of Chicago, Chicago, Ill.
CLAPP, PROF. CORNELIA M., Mount Holyoke College, South Hadley, Mass.
CLARK, PROF. E. R., University of Missouri, Columbia, Mo.
CLOWES, PROF. G. H. A., Eli Lilly Co., Indianapolis, Ind.
COE, PROF. W. R., Yale University, New Haven, Conn.
COHN, DR. EDWIN J., 25 Follen St., Cambridge, Mass.
COLE, DR. LEON J., College of Agriculture, Madison, Wis.
COLLETT, DR. MARY E., University of Buffalo, Buffalo, N. Y.
COLTON, PROF. H. S., Ardmore, Pa.
COOLIDGE, MR. C. A., Ames Building, Boston, Mass.
COPELAND, PROF. MANTON, Bowdoin College, Brunswick, Maine.
COUTANT, MRS. MARY W., Barnard College, Columbia University, New York City.
COWDRY, DR. E. V., Rockefeller Institute, New York City, N. Y.
CRAMPTON, PROF. H. E., Barnard College, Columbia University, New York City.
CRANE, MRS. C. R., Woods Hole, Mass.
CURTIS, PROF. W. C., University of Missouri, Columbia, Mo.
CURTIS, DR. MAYNIE R., Crocker Laboratory, Columbia University, New York City.
DANCHAKOFF, DR. VERA, College of Physicians and Surgeons, New York City.
DAVIS, DR. DONALD W., College of William and Mary, Williamsburg, Va.
DAVIS, PROF. BRADLEY M., University of Michigan, Ann Arbor, Mich.
DAVIS, DR. ALICE R., Harvard Medical School, Boston, Mass.
DAWSON, DR. J. A., Dalhousie University, Halifax, Nova Scotia.

DEDERER, DR. PAULINE H., Connecticut College, New London, Conn.

DERICK, PROF. CARRIE M., McGill University, Montreal, Canada.

DEXTER, DR. J. S., University of Saskatchewan, Saskatoon, Saskatchewan.

DODDS, PROF. G. S., Medical School, University of West Virginia, Morgantown, W. Va.

DONALDSON, PROF. H. H., Wistar Institute of Anatomy and Biology, Philadelphia, Pa.

DONALDSON, DR. JOHN C., University of Pittsburgh, School of Medicine, Pittsburgh, Pa.

DREW, PROF. GILMAN A., Marine Biological Laboratory, Woods Hole, Mass.

DUNGAY, DR. NEIL S., Carleton College, Northfield, Minn.

DUNN, DR. ELIZABETH H., Woods Hole, Mass.

EDWARDS, DR. D. J., Cornell University Medical College, New York City.

EIGENMANN, PROF. C. H., University of Indiana, Bloomington, Ind.

ELLIS, DR. F. W., Monson, Mass.

FARNUM, MISS LOUISE W., 43 Hillhouse Ave., New Haven, Conn.

FIELD, MISS HAZEL E., Sophie Newcomb College, New Orleans, La.

FINLEY, DR. CHARLES W., Lincoln School, New York City.

FISHER, MISS MARY J., Cornell University, Ithaca, N. Y.

FRANKLIN, DR. CHRISTINE LADD, New York City, N. Y.

GAGE, PROF. S. H., Cornell University, Ithaca, N. Y.

GARREY, PROF. W. E., Tulane University, Richardson Memorial, New Orleans, La.

GATES, PROF. R. RUGGLES, University of London, London, England.

GLASER, PROF. O. C., Amherst College, Amherst, Mass.

GLASER, PROF. R. W., Rockefeller Institute for Medical Research, Princeton, N. J.

GOLDFARB, PROF. A. J., College of the City of New York, New York City.

GOODRICH, DR. H. B., Wesleyan University, Middletown, Conn.

GRAVE, PROF. CASWELL, Washington University, St. Louis, Mo.

GRAVE, PROF. B. H., Wabash College, Crawfordsville, Ind.
GREGORY, DR. LOUISE H., Barnard College, Columbia University, New York City.
GREENMAN, PROF. M. J., Wistar Institute of Anatomy and Biology, Philadelphia, Pa.
GUNTHER, MISS MAUDE C., Business High School, Washington, D. C.
GUYER, PROF. M. F., University of Wisconsin, Madison, Wis.
HANCE, DR. ROBERT T., North Dakota Agricultural College, Fargo, N. D.
HARGITT, PROF. C. W., Syracuse University, Syracuse, N. Y.
HARGITT, PROF. GEORGE T., Syracuse University, Syracuse, N. Y.
HARMAN, DR. MARY T., Kansas State Agricultural College, Manhattan, Kans.
HARPER, PROF. R. A., Columbia University, New York City.
HARRISON, PROF. Ross G., Yale University, New Haven, Conn.
HARVEY, PROF. E. N., Princeton University, Princeton, N. J.
HARVEY, MRS. E. N., Princeton, N. J.
HAYDEN, MISS MARGARET A., Wellesley College, Wellesley, Mass.
HEATH, PROF. HAROLD, Palo Alto, Calif.
HEGNER, PROF. R. W., Johns Hopkins University, Baltimore, Md.
HEILBRUNN, DR. L. V., University of Michigan, Ann Arbor, Mich.
HESS, PROF. WALTER N., DePauw University, Greencastle, Ind.
HINRICHS, MISS MARIE A., University of Chicago, Chicago, Ill.
HOADLEY, MR. LEIGH, University of Chicago, Chicago, Ill.
HOAR, MR. D. BLAKELY, 161 Devonshire St., Boston, Mass.
HOGUE, DR. MARY J., Johns Hopkins Medical School, Baltimore, Md.
HOLMES, PROF. S. J., University of California, Berkeley, Calif.
HOOKER, PROF. D. R., Johns Hopkins Medical School, Baltimore, Md.
HOSKINS, MRS. ELMER R., University of Arkansas Medical School, Little Rock, Ark.
HOWE, DR. H. E., National Research Council, Washington, D. C.
HOWLAND, MISS RUTH B., Sweet Briar College, Sweet Briar, Va.
HOYT, DR. WILLIAM D., Washington and Lee University, Lexington, Va.
HYDE, DR. IDA H., University of Kansas, Lawrence, Kans.

HYMAN, DR. LIBBIE H., University of Chicago, Chicago, Ill.
JACKSON, PROF. C. M., University of Minnesota, Minneapolis, Minn.
JACOBS, PROF. MERKEL H., University of Pennsylvania, Philadelphia, Pa.
JENNINGS, PROF. H. S., Johns Hopkins University, Baltimore, Md.
JEWETT, PROF. J. R., Harvard University, Cambridge, Mass.
JOHNSON, PROF. GEORGE E., University of Porto Rico, Rio Piedras, P. R.
JONES, PROF. LYNDS, Oberlin College, Oberlin, Ohio.
JONES, PROF. L. R., National Research Council, Washington, D. C.
JORDAN, PROF. H. E., University of Virginia, Charlottesville, Va.
JUST, PROF. E. E., Howard University, Washington, D. C.
KENNEDY, DR. HARRIS, Readville, Mass.
KINDRED, DR. J. E., Western Reserve University, Cleveland, Ohio.
KING, DR. HELEN D., Wistar Institute of Anatomy and Biology, Philadelphia, Pa.
KING, DR. ROBERT L., University of Pennsylvania, Philadelphia Pa.
KINGSBURY, PROF. B. F., Cornell University, Ithaca, N. Y.
KINGSLEY, PROF. J. S., University of Illinois, Urbana, Ill.
KIRKHAM, DR. W. B., 100 Mill St., Springfield, Mass.
KNOWER, PROF. H. McE., University of Cincinnati, Cincinnati, Ohio.
KNOWLTON, PROF. F. P., Syracuse University, Syracuse, N. Y.
KOSTIR, DR. W. J., Columbia University, New York City.
KRIBS, DR. HERBERT, University of Pennsylvania, Philadelphia, Pa.
KUYK, DR. MARGARET P., Richmond, Va.
LANCEFIELD, DR. D. E., University of Oregon, Eugene, Ore.
LANE, PROF. HENRY H., State University of Oklahoma, Norman, Okla.
LANGE, DR. MATHILDE M., Wheaton College, Norton, Mass.
LEE, PROF. F. S., 437 West 59th St., New York City.
LEFEVRE, PROF. GEORGE, University of Missouri, Columbia, Mo.
LEWIS, PROF. I. F., University of Virginia, Charlottesville, Va.
LEWIS, PROF. W. H., Johns Hopkins University, Baltimore, Md.
LILLIE, PROF. FRANK R., University of Chicago, Chicago, Ill.

LILLIE, PROF. R. S., Nela Research Laboratory, Nela Park, Cleveland, Ohio.

LINTON, PROF. EDWIN, 1408 Rosemary Lane, Columbia, Mo.

LOEB, PROF. JACQUES, Rockefeller Institute for Medical Research, New York City.

LOEB, PROF. LEO, Washington University Medical School, St. Louis, Mo.

LOWTHER, MRS. FLORENCE DEL., Barnard College, Columbia University, New York City.

LUND, DR. E. J., University of Minnesota, Minneapolis, Minn.

LUSCOMBE, MR. W. O., Woods Hole, Mass.

LYMAN, PROF. GEORGE R., Plant Disease Survey, Department of Agriculture, Washington, D. C.

LYNCH, MISS CLARA J., 434 West 120th St., New York City.

LYON, PROF. E. P., University of Minnesota, Minneapolis, Minn.

MACCALLUM, DR. G. A., 925 St. Paul St., Baltimore, Md.

MCCLUNG, PROF. C. E., University of Pennsylvania, Philadelphia, Pa.

MCGEE, DR. A. N., Woods Hole, Mass.

MCGILL, DR. CAROLINE, Murray Hospital, Butte, Montana.

MCGREGOR, DR. J. H., Columbia University, New York City.

MCINDOO, DR. N. E., Bureau of Entomology, Washington, D. C.

MCMURRICH, PROF. J. P., University of Toronto, Toronto, Canada.

MACKLIN, DR. CHARLES C., School of Medicine, Western University, London, Canada.

MALONE, PROF. E. F., University of Cincinnati, Cincinnati, Ohio.

MARTIN, MISS BERTHA E., Mount Holyoke College, South Hadley, Mass.

MAST, PROF. S. O., Johns Hopkins University, Baltimore, Md.

MATHEWS, PROF. A. P., University of Cincinnati, Cincinnati, Ohio.

MATSUI, PROF. K., Imperial College of Agriculture and Dendrology, Morioka, Japan.

MAYOR, PROF. A. G., Maplewood, N. J.

MEIGS, DR. E. B., Dairy Division Experiment Station, Beltsville, Md.

MEIGS, MRS. E. B., 1445 Rhode Island Ave., Washington, D. C.

MEDES, DR. GRACE, Vassar College, Poughkeepsie, N. Y.

METCALF, PROF. M. M., Oberlin College, Oberlin, Ohio.
METZ, PROF. CHARLES W., Carnegie Institution of Washington, Cold Spring Harbor, Long Island.
MINER, DR. ROY W., American Museum of Natural History, New York City.
MITCHELL, DR. PHILIP H., Brown University, Providence, R. I.
MOORE, PROF. GEORGE T., Missouri Botanical Garden, St. Louis, Mo.
MOORE, DR. CARL R., University of Chicago, Chicago, Ill.
MOORE, PROF. J. PERCY, University of Pennsylvania, Philadelphia, Pa.
MOORE, DR. A. R., Rutgers College, New Brunswick, N. J.
MOORE, MISS DOROTHEA M., 21 Kirkland St., Cambridge, Mass.
MORGAN, PROF. H. A., Agricultural Experiment Station, Knoxville, Tenn.
MORGAN, DR. ANNA H., Mount Holyoke College, South Hadley, Mass.
MORRILL, PROF. A. D., Hamilton College, Clinton, N. Y.
MORRILL, PROF. C. V., Cornell University Medical College, New York City.
MULLER, DR. H. J., University of Texas, Austin, Texas.
NABOURS, DR. R. K., Kansas State Agricultural College, Manhattan, Kans.
NACHTRIEB, PROF. HENRY F., University of Minnesota, Minneapolis, Minn.
NEAL, PROF. H. V., Tufts College, Tufts College, Mass.
NEWMAN, PROF. H. H., University of Chicago, Chicago, Ill.
NICHOLS, DR. M. LOUISE, 3221 Race St., Philadelphia, Pa.
NONIDEZ, DR. JOSE F., Cornell University Medical College, New York City.
OKKELBERG, DR. PETER, University of Michigan, Ann Arbor, Mich.
OSBURN, PROF. R. C., Ohio State University, Columbus, Ohio.
OSTERHOUT, PROF. W. J. V., Harvard University, Cambridge, Mass.
PACKARD, DR. CHARLES, Union Medical College, Peking, China.
PACKARD, DR. W. H., Bradley Polytechnic Institute, Peoria, Ill.
PAPPENHEIMER, DR. A. M., Columbia University, New York City.

PARKER, PROF. G. H., Harvard University, Cambridge, Mass.
PATON, PROF. STEWART, Princeton University, Princeton, N. J.
PATTEN, PROF. WILLIAM, Dartmouth College, Hanover, N. H.
PATTERSON, PROF. J. T., University of Texas, Austin, Texas.
PAYNE, PROF. F., University of Indiana, Bloomington, Ind.
PEARL, PROF. RAYMOND, Johns Hopkins University, Baltimore, Md.
PEARSE, PROF. A. S., University of Wisconsin, Madison, Wis.
PEEBLES, PROF. FLORENCE, Bryn Mawr College, Bryn Mawr, Pa.
PHILLIPS, MISS RUTH L., Western College, Oxford, Ohio.
PHILLIPS, DR. E. F., Department of Agriculture, Washington, D. C.
PIKE, PROF. FRANK H., 437 West 59th St., New York City, N. Y.
PINNEY, MISS MARY E., Lake Erie College, Painesville, Ohio.
PLOUGH, PROF. HAROLD H., Amherst College, Amherst, Mass.
POND, DR. SAMUEL E., Nela Research Laboratory, Nela Park, Cleveland, Ohio.
PORTER, MRS. M. B., 310 East 21st St., Austin, Texas.
PRATT, DR. FREDERICK H., Boston University School of Medicine, Boston, Mass.
PRICE, DR. WESTON A., 10111 Euclid Ave., Cleveland, Ohio.
RANKIN, PROF. W. M., Princeton University, Princeton, N. J.
REA, DR. PAUL M., Charleston Museum, Charleston, S. C.
REDFIELD, DR. ALFRED C., Harvard Medical School, Boston, Mass.
REINKE, DR. E. E., Vanderbilt University, Nashville, Tenn.
RICE, PROF. EDWARD L., Ohio Wesleyan University, Delaware, Ohio.
RICHARDS, PROF. A., University of Oklahoma, Norman, Okla.
RICHARDS, MRS. A., Norman, Okla.
RHODES, PROF. ROBERT C., Emory University, Atlanta, Ga.
ROBERTSON, PROF. W. R. B., University of Kansas, Lawrence, Kans.
ROGERS, PROF. CHARLES G., Oberlin College, Oberlin, Ohio.
ROMER, DR. ALFRED S., Columbia University, New York City.
RUDISCH, DR. J., Mount Sinai Hospital, New York City, N. Y.
SAMPSON, MISS MYRA M., Smith College, Northampton, Mass.
SANDS, MISS ADELAIDE G., 348 N. Main St., Port Chester, N. Y.
SANDS, DR. GEORGIANA, 348 N. Main St., Port Chester, N. Y.

Scott, Dr. Ernest L., Columbia University, New York City, N. Y.

Scott, Prof. G. G., College of the City of New York, New York City.

Scott, Prof. John W., University of Wyoming, Laramie, Wyo.

Schrader, Dr. Franz, Bryn Mawr College, Bryn Mawr, Pa.

Shull, Prof. A. Franklin, University of Michigan, Ann Arbor, Mich.

Shumway, Dr. Waldo, Dartmouth College, Hanover, N. H.

Sivickis, Mr. P. B., University of Chicago, Chicago, Ill.

Smith, Dr. Bertram G., 416 West 118th St., New York City.

Snow, Miss Laetitia M., Wellesley College, Wellesley, Mass.

Snyder, Prof. Charles D., Johns Hopkins University, Baltimore, Md.

Sollmann, Dr. Torald, Western Reserve University, Cleveland, Ohio.

Spaeth, Dr. Reynold A., School of Public Health, Johns Hopkins University, Baltimore, Md.

Speidel, Dr. Carl C., University of Virginia, Charlottesville, Va.

Spencer, Prof. H. J., 123 Waverley Place, New York City.

Stockard, Prof. C. R., Cornell University Medical College, New York City.

Stokey, Dr. Alma G., Mount Holyoke College, South Hadley, Mass.

Streeter, Prof. George L., Johns Hopkins University Medical School, Baltimore, Md.

Strong, Prof. O. S., Columbia University, New York City.

Strong, Prof. R. M., Loyola University School of Medicine, Chicago, Ill.

Sturtevant, Dr. Alfred H., Columbia University, New York City.

Tashiro, Dr. Shiro, Medical College, University of Cincinnati, Cincinnati, Ohio.

Taylor, Miss Katherine A., Cascade, Washington Co., Md.

Tennent, Prof. D. H., Bryn Mawr College, Bryn Mawr, Pa.

Tharaldsen, Prof. C. E., Northwestern University, Evanston, Ill.

THOMPSON, PROF. CAROLINE B., 9 Leighton Road, Wellesley, Mass.

TINKHAM, MISS FLORENCE L., 71 Ingersoll Grove, Springfield, Mass.

TOMPKINS, MISS ELIZABETH M., 134 Linden Ave., Brooklyn, N. Y.

TRACY, PROF. HENRY C., University of Kansas, Lawrence, Kans.

TREADWELL, PROF. A. L., Vassar College, Poughkeepsie, N. Y.

TURNER, DR. C. L., Beloit College, Beloit, Wis.

UHLEMEYER, MISS BERTHA, Washington University, St. Louis, Mo.

UHLENHUTH, DR. EDUARD, Rockefeller Institute for Medical Research, New York City.

VAN DER HEYDE, DR. H. C., Heemstede, Holland.

VISSCHER, DR. JOHN P., Washington University, St. Louis, Mo.

WAITE, PROF. F. C., Western Reserve University Medical School, Cleveland, Ohio.

WALLACE, DR. LOUISE B., Constantinople College, Constantinople, Turkey.

WARD, PROF. H. B., University of Illinois, Urbana, Ill.

WARDWELL, DR. E. H., Chappaqua, N. Y.

WARREN, PROF. HOWARD C., Princeton University, Princeton, N. J.

WARREN, DR. HERBERT S., Columbia University, New York City, N. Y.

WASTENEYS, PROF. HARDOLPH, University of Toronto, Toronto, Canada.

WATSON, DR. FRANK E., Hobart College, Geneva, N. Y.

WENRICH, DR. D. H., University of Pennsylvania, Philadelphia, Pa.

WERBER, DR. E. I., 134 West 93d St., New York City, N. Y.

WHEELER, PROF. W. M., Bussey Institution, Forest Hills, Mass.

WHERRY, DR. W. B., Cincinnati Hospital, Cincinnati, Ohio.

WHITE, DR. E. GRACE, Shorter College, Rome, Ga.

WHITESIDE, MISS BEATRICE, 122 West 79th St., New York City, N. Y.

WHITNEY, DR. DAVID D., University of Nebraska, Lincoln, Nebr.

WHITING, DR. PHINEAS W., University of Iowa, Iowa City, Iowa.

WIEMAN, PROF. H. L., University of Cincinnati, Cincinnati, Ohio.
WILCOX, DR. ALICE W., 417 West 120th St., New York City, N. Y.
WILDMAN, PROF. E. E., 47th and Walnut Sts., Philadelphia, Pa.
WILLIAMS, DR. ANNA W., 549 Riverside Drive, New York City, N. Y.
WILLIER, DR. B. H., University of Chicago, Chicago, Ill.
WILSON, PROF. H. V., University of North Carolina, Chapel Hill, N. C.
WOGLOM, PROF. WILLIAM H., Columbia University, New York City, N. Y.
WOODRUFF, PROF. L. L., Yale University, New Haven, Conn.
WOODWARD, DR. ALVALYN E., Amherst College, Amherst, Mass.
YOUNG, DR. D. B., Carleton College, Northfield, Minn.
YOUNG, PROF. ROBERT T., University of North Dakota, University, N. Dak.
ZELENY, DR. CHARLES, University of Illinois, Urbana, Ill.

STUDIES ON THE NECESSITY OF THE BRAIN FOR THE INCEPTION OF INSECT METAMORPHOSIS.

STEFAN KOPEĆ,

GOVERNMENT INSTITUTE FOR AGRICULTURAL RESEARCH, PULAWY, POLAND.[1]

WITH 2 TABLES AND 4 FIGURES IN TEXT.

CONTENTS.

A. The influence of the brain on the inception of the metamorphotic processes..... 325
B. The nature of the influence exerted by the brain on the course of metamorphosis..... 328
C. The independence of the further processes of metamorphosis..... 333
D. General conclusions and summary..... 338

Gudernatsch ('12, '14) was the first to describe the acceleration of metamorphosis in tadpoles fed on thyroid. These results were confirmed for different amphibians by Laufberger ('13), Cotronei ('14), Brendgen ('14), Abderhalden ('15, '19), Kaufman ('17, '18), Kahn ('16), Hirschler ('18–'19), etc., and first of all by Romeis ('14–'19). Adler ('16) ascertained that changes of temperature of the environment cause changes of celerity of metamorphosis in tadpoles, together with simultaneous differences in the structure of the thyroid.

The results of the investigations of Loeb ('96) and Wintrebert ('05–'11), who cut the spinal cord or the nerves of larvæ, contradict the influence of the brain on metamorphosis of amphibians, or at least the influence by means of nerves. On the other hand, Babák ('05) examined the brain of the toad and came to the conclusion that the hind part of the brain affects metamorphosis, since, when it is removed, the processes are arrested. He lays stress on the fact that the removal of the brain effects the changes described only in case the animal is operated upon before the first pair of limbs have grown. Babák ('13) believes that here we have the influence of hypophysis by means of chemical stimuli. Guder-

[1] Paper from the Embryologico-Biological Laboratory, Jagellonian University, Cracow, Poland, presented in the Acad. of Sc., Cracow. *Cf.* Bull. Acad. d. Sc. Cracovie, 1917.

natsch ('12, '14) by feeding tadpoles on hypophysis did not bring about—it is true—any changes in the rate of development, but there is no doubt that feeding experiments with a certain organ may be considered as decisive only if their results are positive, a fact which is not well understood by certain investigators. In fact, Adler ('14), Smith ('16), and Allen ('16, '17) confirm that the processes of metamorphosis in tadpoles are arrested by removal of the hypophysis, which, however, is accompanied by changes in the thyroid. On the other hand, Rogers ('18) and Larson ('19) described changes of the hypophysis brought about by removal of the thyroid in tadpoles, and Allen ('18) confirmed the fact that tadpoles deprived of their thyroid do not undergo metamorphosis. The question arises, therefore, whether the essential and decisive factor which regulates the transformation in those animals is the function of the hypophysis or of the thyroid. Hirschler ('18–'19) ascertained that metamorphosis is accelerated by injecting axolotls with iodoform or iodin. From the recent researches made by Swingle ('19*a* and *b*), who succeeded in transforming tadpoles deprived of their thyroid by feeding them on iodin with flour, as well as from his own analogous experiments, Allen ('19) draws the general conclusion that the metamorphosis of amphibians depends on iodin stored by the thyroid, and that its secretory function is regulated by the hypophysis.

The relationship of the ganglia of the head to metamorphosis in insects has been studied by Conte and Vaney ('11). These authors made ligatures between the head and the body of caterpillars of *Lymantria dispar* L. and obtained adult moths. They infer from their experiments that the ganglia of the head are of no importance for these processes. The following pages show, however, that their conclusion is false. We shall see that the brain (ganglion supra-œsophageale) exerts a great influence on metamorphosis of insects, and the cause of the erroneous conclusion will be clearly explained.

If we wish to investigate the relation which probably exists between the nervous system and the processes of metamorphosis of insects, we must first of all decide whether, after the removal of single parts of the nervous system, the rate of metamorphosis is in general the same as in normal animals, whether it undergoes ac-

celeration or retardation, or whether it is completely arrested. The problem was to find out a possibly well-defined center which would have a more or less decisive influence on the time of inception or on the rate of metamorphosis. Further, we must consider the means by which this hypothetical influence could act on the processes of metamorphosis. The mechanism of this influence ought to be studied by means of special experiments, and the time at which the influence begins to act ought to be found out. In order to answer this question, I operated on female caterpillars of *Lymantria dispar* L. after their last moult. Thus I was able to consider only the processes of the pupation of caterpillars and the emergence of the adult moths, without taking into consideration the processes of the larval moult.

It must be distinctly remarked that the whole material, experimental as well as that used as a control, came from eggs of one female only. All the caterpillars were reared in precisely identical conditions. Moulting, pupation, and emergence of moths were controlled every 12 hours; thus the error in determining the length of life of caterpillars and chrysalids (see Tables I. and II.) could not exceed 24 hours.

As to the methods of removal of single ganglia, cf. operations in my former paper (Kopeć, '18).

A. The Influence of the Brain on the Inception of the Processes of Metamorphosis.

The behavior of caterpillars of *Lymantria dispar* L. deprived of their brain (ganglion supra-œsophageale) allows us to draw the conclusion that this ganglion has a quite specific quality, very important to the whole organism, and characterizing the brain as an organ which excites histolytical processes in the caterpillar and regulates the time of inception of the general processes of pupation. Let us consider the data given in Table I., which refer to the pupation or to the death of caterpillars, whether normal, brainless, or those used as a control, viz., specimens which have been injured in the same manner as the caterpillars deprived of their brain, and which, in spite of the presence of the brain, refused food as well as the brainless specimens. All these specimens (exclu-

sively females) were operated upon on the seventh day after their last moult and lived under the same conditions of heat, light, and humidity. We see that out of 25 brainless caterpillars only 5 underwent pupation, and in these the instant of beginning pupation exhibits a certain retardation in comparison with the behavior of the specimens used as a control. It is evident that the majority of the brainless caterpillars did not undergo metamorphosis, remained alive for weeks, and did not die until the whole store of fat in their body had been completely exhausted. Large full-blooded and fat caterpillars of 4–5 cm. in length become small during this period, and were often scarcely 1 cm. long in their final state. At the same time their bodies shrank and almost completely dried up, their movements became fainter and fainter, until at last they died. Caterpillars deprived of their brain do not, as a rule, die after the operation as a result of any disease induced by the removal of the brain, but, on the contrary, they live relatively very long. Only a few specimens die soon after operation as a consequence of mechanical injuries taking place during the removal of the brain. The essential difference between these insects and those used as a control lies only in the fact that histolytical processes subsequently followed by metamorphosis can begin only in animals the brain of which has exerted a proper stimulus at the proper time. It is certain that the few brainless caterpillars which succeeded in becoming pupæ attained the stage only because the brain had already influenced the tissues before its removal. In this function, too, the animals exhibit individual fluctuations; here we evidently see specimens in which the brain had begun to perform its stimulative part very early, or had exerted it very quickly. It ought to be admitted that, if we could succeed in feeding brainless specimens, their life could be still longer. These caterpillars, however, would probably not undergo metamorphosis.

The opinion that the brain is of importance for metamorphosis is supported by the following observations, which prove also that the influence discussed sets in at a somewhat definite period, viz., in females of *Lymantria dispar* L. in my breed between the seventh and tenth day after their last moult. Let us observe the behavior of the caterpillars which were deprived of their brain not on the seventh day after the last moult as in investigations hitherto con-

TABLE I. BEHAVIOR OF THE FEMALE CATERPILLARS OPERATED UPON ON THE SEVENTH DAY AFTER THEIR LAST MOULT.
p. = pupation; d. = death of caterpillars.

Caterpillars Deprived of the Brain.			Caterpillars Deprived of the Subœsophageal Ganglion (Brain Intact).			Caterpillars Used as a Control; Injuries of the Head as in Caterpillars Deprived of Brain (Brain Intact).			Normal Caterpillars.		
Number Corresponding to Each Specimen.	Behavior of the Caterpillar.	Number of Days the Pupa Lived till the Emergence of the Moth.	Number Corresponding to Each Specimen.	Behavior of the Caterpillar.	Number of Days the Pupa Lived till the Emergence of the Moth.	Number Corresponding to Each Specimen.	Behavior of the Caterpillar.	Number of Days the Pupa Lived till the Emergence of the Moth.	Number Corresponding to Each Specimen.	Behavior of the Caterpillar.	Number of Days the Pupa Lived till the Emergence of the Moth.
1	After 12½ days p.	—	1	After 7½ days p.	—	1	After 6½ days p.	21	1	After 6½ days p.	19
2	" 12½ " p.	19	2	" 8½ " p.	17	2	" 6½ " p.	21	2	" 7 " p.	20½
3	" 14 " d.		3	" 8½ " p.	17	3	" 7 " d.		3	" 7½ " p.	20
4	" 14½ " p.	17	4	" 9 " p.	20½	4	" 7½ " p.	21	4	" 8½ " p.	20
5	" 14½ " p.	—	5	" 9½ " p.	18½	5	" 7½ " p.	—	5	" 8½ " p.	18½
6	" 15 " d.		6	" 9½ " p.	20	6	" 8 " p.	22	6	" 8½ " p.	22
7	" 15 " d.		7	" 10 " d.		7	" 8 " p.	20½	7	" 8½ " p.	20
8	" 15 " d.		8	" 10 " p.	19½	8	" 8 " p.	18½	8	" 8½ " p.	18
9	" 16 " d.		9	" 12½ " p.	16	9	" 8½ " p.	22	9	" 9 " p.	20½
10	" 16 " d.		10	" 12½ " p.	19½	10	" 8½ " p.	—	10	" 9 " p.	17
11	" 16½ " p.	21	11	" 12½ " p.	18	11	" 9 " p.	21½	11	" 9 " p.	18
12	" 17 " d.		12	" 14 " p.	17	12	" 9 " p.	22½	12	" 9½ " p.	18
13	" 17½ " d.		13	" 14 " p.	19	13	" 10½ " p.	21	13	" 9½ " p.	17
14	" 17½ " d.					14	" 11 " d.		14	" 9½ " p.	17
15	" 21½ " d.					15	" 11½ " d.		15	" 10 " p.	20½
16	" 22½ " d.					16	" 12 " p.	17	16	" 10 " p.	19
17	" 22½ " d.								17	" 10 " p.	21½
18	" 23 " d.								18	" 13 " p.	19
19	" 23 " d.										
20	" 23 " d.										
21	" 25 " d.										
22	" 25 " d.										
23	" 27 " d.										
24	" 31 " d.										
25	" 31 " d.										

sidered, but three days later. From Table II. it is evident that here the percentages are quite different: almost all caterpillars undergo pupation. The specimens which did not succeed in becoming pupæ live no longer than the normal larvæ and their death evidently results from the injuries of the operation. In this case the metamorphosis of the caterpillars operated upon does not undergo any retardation.

The above-mentioned experiments of Conte and Vaney ('11) must have been performed on such older specimens. In my previous paper (Kopeć, '12), in which, like the authors mentioned, I stated that the nervous system is unimportant up to the time of pupation, I relied only on full-grown specimens; in view of my present data, the former opinion can no longer be upheld. It follows from further operations that none of the other nervous ganglia (in contrast to the brain) has any influence on the time of pupation.

The dependence of the metamorphosis of the insect on its brain, already discussed, and its independence of the other ganglia, may be observed in one and the same specimen by means of a special method of cutting the caterpillars. Having made ligatures with strong silk round the body of the caterpillar into places chosen *ad libitum,* and having made a section between the ligatures, we may obtain two separate parts from one caterpillar, both of which are able to live. For instance, in one series of experiments the caterpillars were operated upon 7 days after their last moult, and it was found that the parts composed of the head and a few segments of the larval body attained the stage of pupation in from 7 to 9 days after the time of operation. Larger or smaller parts of the hind segments of the body devoid of the brain did not succumb till 35 days after the operation, but at death they exhibited no traces of histolytical processes. When caterpillars a few days older were operated upon both fragments underwent pupation at the normal time.

B. The Nature of the Influence Exerted by the Brain on the Course of Metamorphosis.

If the influence exerted by the brain on the course of metamorphosis were by means of nerves, it might be supposed that the

TABLE II. BEHAVIOR OF THE FEMALE CATERPILLARS OPERATED UPON ON THE TENTH DAY AFTER THEIR LAST MOULT.
p. = pupation; d. = death of caterpillars.

Caterpillars Deprived of the Brain.			Caterpillars Deprived of the Subœsophageal Ganglion (Brain Intact).			Caterpillars Used as a Control; Injuries of the Head as in Caterpillars Deprived of Brain (Brain Intact).			Normal Caterpillars		
Number Corresponding to Each Specimen.	Behavior of the Caterpillar.	Number of Days the Pupa Lived till the Emergence of the Moth.	Number Corresponding to Each Specimen.	Behavior of the Caterpillar.	Number of Days the Pupa Lived till the Emergence of the Moth.	Number Corresponding to Each Specimen.	Behavior of the Caterpillar.	Number of Days the Pupa Lived till the Emergence of the Moth.	Number Corresponding to Each Specimen.	Behavior of the Caterpillar.	Number of Days the Pupa Lived till the Emergence of the Moth.
1	After 3 days p.	—	1	After 3½ days p.	21	1	After 4 days p.	19½	1	After 3 days p.	20
2	" 3½ " p.	—	2	" 3½ " p.	—	2	" 4 " p.	20½	2	" 4 " p.	21
3	" 4 " p.	21	3	" 4½ " p.	—	3	" 5 " p.	19½	3	" 5 " p.	20
4	" 4 " p.	22	4	" 5 " p.	19½	4	" 5 " p.	19½	4	" 5 " p.	20½
5	" 4 " p.	22	5	" 5 " p.	18½	5	" 5½ " p.	17½	5	" 5 " p.	21
6	" 4 " p.	21	6	" 5 " p.	18½	6	" 6 " p.	—	6	" 5½ " p.	20½
7	" 4 " p.	21	7	" 7 " p.	17½	7	" 6½ " p.	18	7	" 6 " p.	20
8	" 4½ " p.	—	8	" 7 " d.		8	" 8½ " p.	—	8	" 6½ " p.	20½
9	" 5½ " p.	21				9	" 9 " p.	17	9	" 8 " p.	19
10	" 7 " d.					10	" 10½ " d.		10	" 8½ " p.	18½
11	" 8 " d.										
12	" 8½ " p.	—									
13	" 9½ " d.										
14	" 10 " p.	17½									
15	" 10½ " p.	19									

removal of the subœsophageal ganglion would have the same effect as the removal of the brain, as in this case the continuity between the brain and the remainder of the central nervous system is disturbed. But the corresponding data of Tables I. and II. prove that in this case the insects behave normally. The behavior of insects which have been deprived of two or three successive ganglia of the thorax or of the abdomen was also similar: both parts of the body, the part situated in front of the place of operation and that behind it, attained the stage of pupation simultaneously, although the connection between the central nervous system of the two parts had been quite destroyed. After several trials, I convinced myself that processes of regeneration never occur, such as would be able to produce a new nervous communication between the two parts.

At most it must be admitted that the brain is connected with the part of the nervous system situated behind the place of operation by means of the "intestinal nervous system," which is composed of very small ganglia lying in the tissue surrounding the œsophagus and connected in front with the brain. (The "sympathetic nervous system" of the caterpillar undergoes rupture during the removal of the ganglia of the nervous chain. For corresponding anatomical data see the paper of Cattie, '80.) Owing to the unusually small size of the intestinal system, it was impossible to study it in greater detail by operating. On the other hand, I do not consider it possible that any nervous conduction between the two parts of the larval body operated upon can take place, since I observed several times that the part of the body behind the segment deprived of its nervous ganglion does not respond to any stimuli exerted on the fore-part of the caterpillar operated upon, and *vice versa*. The fore-segments of the operated body may be sharply pinched, injured, cut, or burned, still the hind part does not perform even the slightest movements referable to the stimuli, although under normal conditions even slight excitations of any part of the body produce violent reflexes. In regard to this, there seems to be no doubt that the fore-part of the body of the operated caterpillars is in no nervous connection with the part situated beyond the place of operation. It is, therefore, most probable that the brain does not influence the general processes of metamorphosis

through the nerves, but that it has rather the function of an organ of internal secretion, in that it affects the organism by means of a substance (or substances) which may be supposed to pass into the blood of the caterpillar from the brain at a certain stage of the larval life. Experiments bearing on the transplantation either of the organized brain or of its matter might perhaps decide whether this conclusion is true. It is most probable that the chemical substance (or substances) here acting is the ferment called "thyrosinase," the aggregation of which during the pupation of insects and the disappearance of which at the end of the pupal life has been previously noticed by Dewitz ('05, '16) and more recently by Steche and Waentig ('13). In his numerous papers Dewitz long ago ascribed an important "rôle" to "thyrosinase" in metamorphotic processes.

The mere observation that the brain has an influence on the inception of histolytical processes in the body of caterpillars gives no idea as to the physiological nature of this influence. The method of removal of the brain from the larval body was not adapted to ascertain whether the proper stimulus effected by the brain is the only factor which excites histolytical processes in the body of the caterpillar, or whether certain physiological changes which appear in the organism coöperate spontaneously and independently of the brain in the same direction. In other words, does the larval organism undergo metamorphosis exclusively because of the stimulus derived from the brain, or is the brain able to act only when certain physiological changes occur in the tissues of the caterpillar, changes without which the influence of the brain must remain powerless? The investigation in this direction had to be made by transplanting the organs of young caterpillars in which these hypothetical physiological changes in the tissues themselves had not yet occurred onto full-grown caterpillars, in which the influence of the brain on the excitement of metamorphosis might already be noticed. Should the grafted organs exhibit acceleration in their development as a consequence of their new surroundings, the metamorphosis of the insects would have to be considered as dependent primarily on the brain, the latter having caused the transformation of the larval organs independently of their age or physiological development. Should this hypothesis prove false,

the coöperation of stimulus of the brain and of the physiological conditions of larval tissues (without which the influence of the brain would have no effect) would appear to be indispensable.

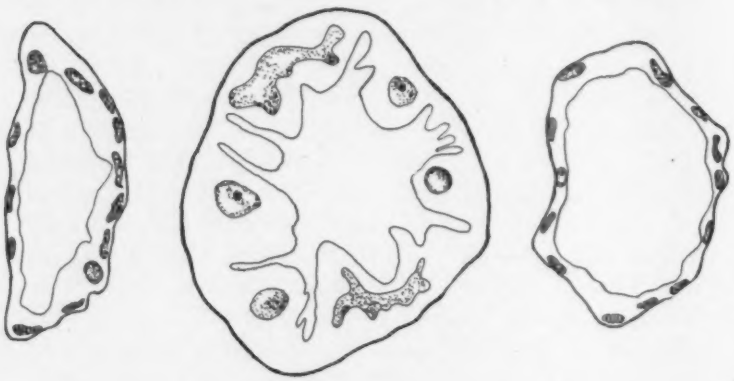
For these transplantations I used the sexual glands. The gonads of moths do not belong to those organs which develop in the chrysalis from the special imaginal discs; they are formed by the growth and histological changes of the small larval sexual glands whose existence has been observed for a long time in caterpillars. All four ovarial tubes of caterpillars hitherto contained in a connective tissue membrane and forming together with it one apparently globular body grow during the caterpillar's pupation to such a degree that they break out of the membrane. In the testes, on the other hand, the characteristic high cylindrical epithelium which lines the interior of that part of the developing spermiduct adjacent to the testicles is formed at that period from the uniform mass of imperfectly separated cells situated at the base of the gland. At the same time the testicle shrinks considerably and its contents become much compacter. I mention these facts in somewhat greater detail than usual in order to emphasize that, although they do not develop from imaginal discs, the sexual glands exhibit certain distinct evolutive changes during their development. As a consequence of this the study of the behavior of the organs after the transplantation is quite suitable for our present purpose. The ovaries and testicles of caterpillars after the third or fourth moult were transferred to full-grown caterpillars which were to undergo pupation in a few days. Hence, in these caterpillars, the substance which excites histolytical processes had already passed over from the brain into the body. It was found that the rate of evolution of the testes and the ovaries grafted remained unchanged, notwithstanding the new surroundings in which the processes of metamorphosis were just beginning or had already begun. From this follows the important conclusion that the stimulus of the brain is inadequate for metamorphosis of the separate organs of insects, and that it is only able to act when the organism, having attained a certain stage of development, is prepared physiologically to respond to the stimulus.

C. The Independence of the Further Processes of Metamorphosis.

I have already mentioned that the brain exerts an influence on the inception of processes of metamorphosis at a certain definite period of the larval life, in females of *Lymantria dispar* L. of my breed between the seventh and tenth day after their last moult. The question arises as to whether this influence, which excites the inception of histolytical processes in caterpillars, at the same time makes the further course of metamorphosis possible, leading to the formation of the imago; or whether brainless chrysalids are unable to become moths. When the caterpillar has been influenced by the brain sufficiently to undergo pupation, the further evolutive processes, which take place in chrysalids, have been shown to occur independently of the brain. By comparing the data relative to the length of life of the chrysalids in various specimens (brainless, those used as standard, and normal) we see, moreover, that even the rate of formation of the imago from the chrysalis undergoes neither retardation nor acceleration when the brain is removed (cf. Tables I. and II.). If a caterpillar deprived of its brain undergoes pupation, the emergence of the moth from the chrysalis takes place at the normal time. The removal of the brain or of other ganglia has merely a local effect in that (as I want to point out in another paper) muscles are completely or almost completely absent in the corresponding segments. The absence of muscles, however, is the result of merely local correlation between the presence of the imaginal muscles and that of the nervous ganglion in a segment of the body, but it has no connection with the influence under discussion—*i.e.*, the influence of the larval brain on the *whole* histolytical and evolutive processes during the metamorphosis of insects in all tissues of the *whole* body.

The following experiments were made to demonstrate the above principle, viz., that the further metamorphosis of insects, having once been excited by the influence of the brain, continues independently in a different manner. Evidence ought to be furnished by the metamorphosis of imaginal discs of single parts of the insectal body, if it should take place independently of the surroundings to which they had been artificially transferred. According to

recent researches on the development of the Malpighian tubes in moths, the cells of the tubes of full-grown insects are derived directly from the cells of the larval tubes through certain physiological and morphological metamorphosis. (Cf. paper of Samson, '08.) By grafting fragments of the larval Malpighian tubes into the head or thorax, I hoped to solve the problem as to whether the metamorphosis of these tubes might occur normally, in anomalous surroundings, even in the absence of a connection between the tubes and the intestine. Smaller or larger parts of the tubes taken



A *B* *C*

from various regions were grafted into the head or the thorax of the same caterpillar after the last moult of the animal: some of the caterpillars operated upon had just accomplished this moult, others had lived already 10 or 11 days after the last moult. In other cases the Malpighian tubes were transplanted from female caterpillars 10 days after their last moult into other caterpillars 2 or 3 days after this moult. After a few days the ends of these implanted parts were healed up, and so the contents could no longer come out. In the adult insect or pupa I several times succeeded in detecting microscopically the presence of the implanted tubes, which were here not united with the intestine. The cells of the tube which developed in the head or the thorax (cf. Fig. *A* in text) exhibited different characters from those observed in the cater-

pillars (Fig. *B*), viz., they corresponded to the normal cells of tubes in the normal adult moth (Fig. *C*). Their height was far lower than in the larval stage of development, sometimes they were twice as low. Their nuclei, having a much more compact chromatine, and a flatter, non-ramified form, were situated nearer the base of the cells. The interior margin of the tubes was not so much notched as in the caterpillar. All these characters prove that the cells of the implanted tubes have undergone normal metamorphosis. This metamorphosis of the Malpighian tubes is consequently independent of the function of this organ, as it is difficult to suppose that the tubes undergoing metamorphosis in heterogeneous surroundings were able to realize their special function in the chrysalis and later in the adult moth, as they were unconnected with the developing intestine, completely grown together and always filled with excrements previously formed during the larval life. If it could be proved without any objection that the Malpighian tubes which have been implanted into the head or thorax had no nervous junction in the new surroundings, the metamorphosis of transplanted fragments of Malpighian tubes would be a further proof for the assertion made in the previous chapter that the brain exerts its influence by means of internal secretion. The probably unchanged rate of metamorphosis of the tubes transferred from caterpillars 10 days after their last moult into those 2 to 3 days after this moult (thus from specimens in which the influence of the brain was already observable into specimens in which there was yet no such influence) points to the conclusion that tissues once stimulated by the brain to transformation undergo further metamorphosis independently.

Should this principle be of general importance, it would be expected that the organs of much older caterpillars (a few days before pupation) grafted on the much younger caterpillars after the fourth moult (and therefore some two to three weeks younger) might also undergo further metamorphosis at the normal rate, in spite of the fact that the organs of the younger specimens do not as yet indicate the slightest trace of the histolytical processes. Transplantations of the germ of wings fully confirmed this hypothesis. I removed the germ of the first left wing from numerous caterpillars shortly before their last moult, and in its place I

grafted an analogous germ derived from a full-grown caterpillar, which was to undergo metamorphosis in a few days. In two of the caterpillars somewhat large and black outgrowths—dwarfed and deformed wings—appeared on the place of grafting. In their uniformly dark hue and the thickness and markings of the chitin they formed a striking contrast to the bright-colored tegument of the caterpillar. (Cf. Fig. *D*.) The small size and the abnormal

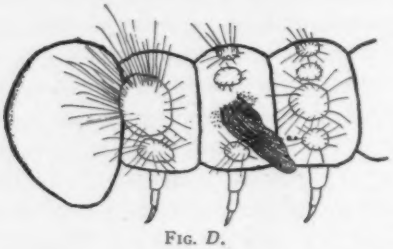


FIG. *D*.

forms were doubtless caused by inevitable injuries of the delicate germ during transplantation, as well as by the difficulty of extracting the pupal wing from the moulting but not pupating caterpillar. Histologically the development of the pupal wings was normal. I have also formerly observed (Kopeć, '11) that the sexual glands of full-grown caterpillars develop at their normal rate when grafted on the caterpillar after their third or fourth moult. Such a behavior of the grafted wings and sexual glands strikingly confirmed the above-stated principle that after the time when the brain has already exerted its influence on the whole organism—which influence decides the inception of histolytical processes leading to the chrysalis stage—the subsequent development and metamorphosis of organs is quite independent of the brain.

The results of my experiments proved that the rate of development of the grafted organs underwent no change due to the influence of new surroundings, differing both as to age and physiological state. These results seem to disagree with analogous researches of Uhlenhuth ('12, '13) on amphibians. This author grafted eyes of salamander larvæ on specimens of a different age and came to the conclusion that the metamorphosis of the transplanted eyes underwent a distinct retardation when grafted on

younger specimens, and an acceleration in the contrary case—*i.e.*, the transplanted as well as the own eyes of the foster-mother underwent metamorphosis at the same time. But the disagreement of these results with the behavior of the transplanted insect organs in my investigations is only apparent. The influence of the surroundings on the grafted eye, observed by Uhlenhuth, was to be remarked only when the age of the specimens on which the eyes were implanted did not differ much from that of animals whose eyes were taken for the operation. In the remaining cases—*i.e.*, under the conditions which alone corresponded to my investigations on the transplantation of organs from young caterpillars after their third or fourth moult to full-grown caterpillars or chrysalids and *vice versa*—the grafted eyes retained their proper developmental rate without being influenced by the new surroundings, just like the organs of insects transplanted in my experiments. Nor do my experiments on insects in any way contradict the experiments of Weigl ('13) which were made simultaneously with but independently of those of Uhlenhuth. Weigl studied the same problem in his investigations on the homo- and heteroplastic transplantation of the skin in salamanders and other amphibians. In regard to the course of the metamorphosis of the grafted pieces of skin, he comes to the same general conclusion as Uhlenhuth. In the experiments of Kornfeld ('14) we can also find a parallel to the results I observed on insects. This author, who transplanted the gill of salamanders, agrees in his final conclusion with Uhlenhuth. Uhlenhuth ('13), mentioning my former experiments on the transplantation of gonads in moths, imputes to me results completely different from those which I really obtained (Kopeć, '11). More recently this error has been corrected by Kornfeld in agreement with Uhlenhuth.

In specimens deprived of the brain or of other nervous ganglia we often may observe certain mechanical difficulties during pupation and emergence of the moth. They are produced by concrescence of the chitin at the place of operation, and cause the appearance of certain deformities of chrysalids or of moths. It must be distinctly noted that all these deformities, caused only by mechanical obstructions during pupation or emergence of the moths, are in no wise dependent on the operation itself, nor conse-

quently on the removal of separate parts of the nervous system. A proof of this is that they also appear—and in the same number of cases—in the specimens with intact nervous system used as a standard and injured similarly as in the operations on the ganglia. Therefore I consider it superfluous to describe these anomalies here.

D. General Conclusions and Summary.

From the whole of this paper it follows that my results relative to the influence of the nervous system on metamorphosis in insects show a very great resemblance to the relations observed in amphibians. According to recent investigations (above mentioned), iodin stored by the thyroid glands in amphibians is the direct cause which elicits metamorphosis, but the production of this substance probably depends on the function of the hypophysis. Consequently in both classes of animals metamorphosis would be controlled by the brain, or part of it. In recent years experiments have been performed on the influence of food containing thyroid or hypophysis on the development of the larvæ of insects, but the results of these researches do not as yet furnish an adequate material for any conclusions. Abderhalden ('19) observed that a part of the moths obtained from caterpillars fed on hypophysis was very large; many specimens from caterpillars fed on thyroid, on the contrary, were very small. These data refer, however, to phenomena of growth, and are possibly quite unrelated to the problem of the rate of transformation here now discussed. Romeis and v. Dobkiewicz ('20) studied the rate of development in larvæ of *Calliphora* fed on thyroid and obtained no distinct changes which might have been attributed exclusively to the specific effect of the thyroid gland. As I mentioned above, negative results of feeding experiments with hypothetical specific influence ought not to be considered as decisive, because it may be inferred from them only that the substance used does not exert any effect on the organism when given *per os*. Hankó ('12), on the other hand, ascertained a very considerable influence of hypophysis on rate of moults in *Asellus aquaticus*. But, as moults in Crustacea are not to be totally identified with moults in insects having complete metamorphosis, these results also have no great importance for our

problem. The whole question demands further research in order to elucidate whether and in what degree there exists an analogy between the physiology of transformation of amphibians and that of insects.

The following summary contains the more important results of this paper:

1. The brain (ganglion supra-œsophageale) of the caterpillar of *Lymantria dispar* L. has particular importance in the general processes of metamorphosis. The presence of the brain is indispensable, at least up to a certain period, for the inception of histolytical processes. The influence of the brain in this direction is probably chemical; hence the brain ought to be considered as a gland of internal secretion.

2. At some well-defined time before pupation the quantity of the corresponding substance (or substances) secreted by the brain is already sufficient for the complete pupation of the caterpillar.

3. Tissues of the caterpillar influenced by the brain undergo further metamorphosis independently; the germs of the wings of caterpillars grafted shortly before pupation on younger caterpillars near their last moult are transformed in the larval organism into pupal wings in spite of the absence of histolytical processes in the new surroundings. Analogical results have been obtained by transplantation of Malpighian tubes and gonads.

4. It follows from other experiments on the transplantation of organs that the stimulus coming from the brain is not sufficient by itself for the metamorphosis of caterpillars: this stimulus acts only when the insect organism, having attained a certain stage, is physiologically prepared to answer to this influence. This is shown by the fact that germs of gonads from young caterpillars grafted into full-grown caterpillars do not undergo metamorphosis characteristic of the pupal development of gonads; in other words, the rate of development underwent no acceleration in spite of the histolytical processes occurring in the new surroundings.

5. Other parts of the nervous system have no influence on the general processes of metamorphosis.

6. By making ligatures round the body of the caterpillar and cutting it in different places, we may obtain fragments consisting of front, middle, or hind segments. The front fragments undergo

metamorphosis in a normal manner, provided the caterpillar does not die of starvation. On the contrary, the middle and hind fragments undergo pupation only if they have belonged to caterpillars which would have pupated in a few days.

7. The Malpighian tubes are transformed into tubes of the adult insect independently of the intestine and of the performance of their specific function.

E. BIBLIOGRAPHY.

Papers marked by an asterisk are known to me only from abstracts.

Abderhalden, E.

* '15 Studien über die von einzelnen Organen hervorgebrachten Substanzen mit spezifischer Wirkung. 1. Mitteilung. Arch. f. d. ges. Physiol., Vol. 162.

'19 2. Mitteilung. Ibidem, Vol. 176.

Adler, L.

'14 Metamorphosestudien an Batrachierlarven. 1. Exstirpation endokriner Drüsen. A. Exstipation der Hypophyse. Arch. f. Entw. Mech., Vol. 39.

'16 Untersuchungen über die Entstehung der Amphibienneotenie. Arch. f. d. ges. Physiol., Vol. 164.

Allen, B. M.

* '16 Extirpation Experiments in *Rana pipens* Larvæ. Science.

'17 Effects of the Extirpation of the Anterior Lobe of the Hypophysis of *Rana pipiens*. Biol. Bull., Vol. 32.

* '18 The Results of Thyroid Removal in the Larvæ of *Rana pipiens*. Journ. of Exper. Zoöl., Vol. 24.

'19 The Relation of the Pituitary and Thyroid Glands of *Bufo* and *Rana* to Iodin and Metamorphosis. Biol. Bull., Vol. 36.

Babák, E.

'05 Ueber die Beziehung des zentralen Nervensystems zu den Gestaltungsvorgängen der Metamorphose des Frosches. Arch. f. d. ges. Physiol., Vol. 109.

'13 Einige Gedanken über die Beziehung der Metamorphose bei den Amphibien zur inneren Secretion. Zentrbl. f. Physiol., Vol. 27.

***Brendgen, F.**

'14 Ueber die künstlich erzielte Metamorphose der Alyteslarven. Anatom. Anzeiger., Vol. 46.

Cattie, J. Th.

'80 Beiträge zur Kenntnis der Chorda Supra-spinalis der Lepidopteren und des zentralen, peripherischen und sympatischen Nervensystems der Raupen. Zeitschr. f. wiss. Zoolog., Vol. 35.

Conte, A. et Vaney, C.

'11 Production expérimentale des Lépidoptères acephales. Comptes Rend. Acad. Sc. Paris, Vol. 152.

***Cotronei, G.**

'14 Première contribution expérimentale à l'étude des rapports des organes dans la croissance et dans la métamorphose des amphibiens anoures. Arch. ital. de Biologie, Vol. 61.

Dewitz, J.

* '05 Untersuchungen über die Verwandlung der Insectenlarven. II. Arch. f. Anat. und Physiol., Physiol. Abt., Suppl.

'16 III. Zusammenfassung früherer Mitteilungen. Zool. Anz., Vol. 47.

Gudernatsch, J. F.

'12 Feeding Experiments on Tadpoles. I. Arch. f. Entw. Mech., Vol. 35.

'14 Feeding Experiments on Tadpoles. II. Amer. Journ. of Anat., Vol. 15.

Hankó, B.

'12 Ueber den Einfluss einiger Lösungen auf die Häutung, Regeneration und das Wachstum von Asellus aquaticus. Arch. f. Entw. Mech., Vol. 34.

Hirschler, J.

'18–'19 Sur la métamorphose provoquée chez l'axolotle à l'aide d'iode et des expérience apparentées. Extrait de Kosmos, Bull. d. l. Soc. Polonaise d. Naturalistes à Leopol.

***Kahn, R. H.**

'16 Zur Frage der Wirkung der Schilddrüse und Thymus auf Froschlarven. Arch. f. d. ges. Physiol., Vol. 163.

Kaufman, L.

'18 Researches on the Artificial Metamorphosis of Axolotls. Bull. de l'Acad. d. Sc. de Cracovie. (Prelim. note, ibidem, 1917.)

Kopeć, St.

'11 Untersuchungen über Kastration und Transplantation bei Schmetterlingen. Arch. f. Entw. Mech., Vol. 33.

'12 Ueber die Funktionen des Nervensystems der Schmetterlinge während der sukzessiven Stadien ihrer Metamorphose. Zool. Anz., Vol. 40.

'18 Lokalisationsversuche am zentralen Nervensystem der Raupen und Falter. Zool. Jahrb., Abt. f. allg. Zool. und Physiol. Bd. 36.

Kornfeld, W.

'14 Abhängigkeit der metamorphotischen Kiemenrückbildung vom Gesamtorganismus der *Salamandra maculosa*. Arch. f. Entw. Mech., Vol. 40.

***Larson, M. E.**

'19 Effects of the Extirpation of the Thyroid Gland upon the Pituitary Gland in *Bufo*. Anat. Record, Vol. 15.

Laufberger, V.

'13 O vzbuzeni metamorfosy axolotlu krmenim zlazou stitnou. Lekaı. Rozhl. Prague.

Loeb, J.

'96 Hat das Zentralnervensystem einen Einfluss auf die Vorgänge der Larvenmetamorphose? Arch. f. Entw. Mech., Vol. 4.

***Rogers, J. B.**

'18 The Effect of Extirpation of the Thyroid upon the Thymus and the Pituitary Glands of *Rana pipiens*. Journ. of Exper. Zoöl., Vol. 24.

Romeis, B.

'14–'15 Experimentelle Untersuchungen über die Wirkung innersekretorischer Organe. II. Arch. f. Entw. Mech., Vol. 40 and 41.

'15 Idem, III. Zeitschr. f. d. ges. experim. Medizin., Vol. 4.

'16 Idem, IV. Ibidem, Vol. 5.

'18 Idem, V. Ibidem, Vol. 6.

'19 Idem, VI. Arch. f. d. ges. Physiol., Vol. 173.

Romeis, B. u. v. Dobkiewicz, L.

'20 Experimentelle Untersuchungen über die Wirkung von Wirbeltierhormonen auf Wirbellose. I. Arch. f. Entw. Mech., Vol. 47.

Samson, K.

'08 Über das Verhalten der Vasa Malpighi und die exkretorische Funktion der Fettzellen während der Metamorphose von Heterogenea limacodes Hufn. Zool. Jahrb., Abt. f. Anat. u. Ontog., Vol. 26.

***Smith, P. E.**

'16a Experimental Ablation of the Hypophysis in the Frog Embryo. Science.

'16b The Effect of Hypophysectomy in the Early Embryo upon the Growth and Development of the Frog. Anat. Record.

***Steche, O. u. Waentig, P.**

'13 Untersuchungen über die biologische Bedeutung und Kinetik der Katalase. Zoologica, Vol. 26.

***Swingle, W. W.**

'19a Studies on the Relation of Iodin to the Thyroid. I. Journ. of Exper. Zoöl., Vol. 27.

'19b Idem, II. Ibidem.

Uhlenhuth, E.

'12 Die Transplantation des Amphibienauges. Arch. f. Entw. Mech., Vol. 33.

'13 Die synchrone Metamorphose transplantierter Salamanderaugen. Ibidem, Vol. 36.

Weigl, R.

'13 Über homoplastische und heteroplastische Hauttransplantation bei Amphibien mit bensonderer Berücksichtigung der Metamorphose. Ibidem, Vol. 36.

Wintrebert, P.

'05a Sur la régression de la queu en l'absence des centres medullaires chez Rana viridis. Comptes rend. Soc. Biol. Paris, Vol. 58.

'05b Sur l'indépendence de la métamorphose vis à vis du systeme nerveux chez les Batraciens. Comptes rend. Acad. Sc. Paris, Vol. 141.

'06a Sur l'accomplissement régulier des fonctions de nutrition, de processus d'ontogenèse, de régenération et de métamorphose chez les larves d'Alytes, en l'absence d'une grande étendue de la moëlle. Comptes rend. Soc. Biol. Paris, Vol. 60.

'06b La métamorphose de Salamandra maculosa Laur. en dehors de la moëlle et de ganglions spinaux. Ibidem.

'11 Sur le déterminisme et la métamorphose chez les Amphibiens. Ibidem, Vol. 71.